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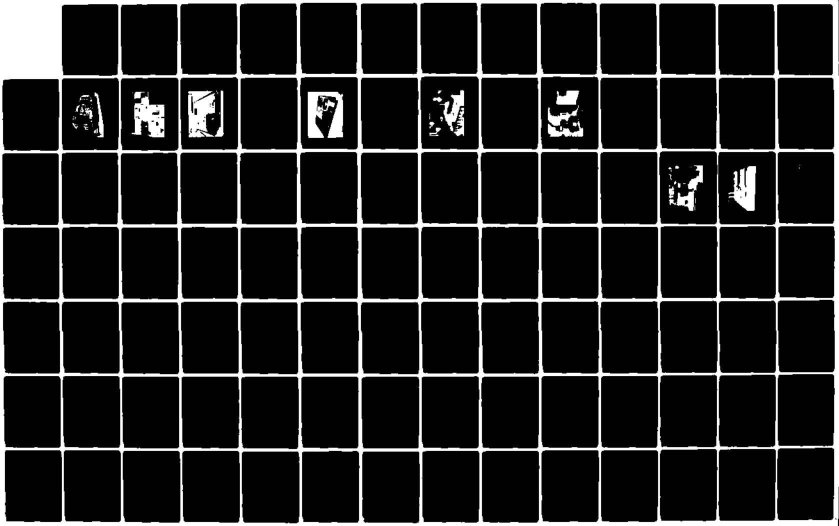

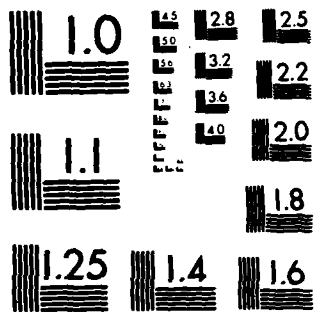

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REPORT SD-TR-83-87

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Certification Vibration Tests, SD802 Materials Experiment

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15 December 1983

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This report was submitted by The Aerospace Corporation, El Segundo, CA 90245, under Contract No. F04701-83-C-0084 with the Space Division, P.O. Box 92960, Worldway Postal Center, Los Angeles, CA 90009. It was reviewed and approved for The Aerospace Corporation by L. R. McCreight, Director, Materials Sciences Laboratory. First Lieutenant Scott L. Hough, SD/YOO, was the project officer for the Mission Oriented Investigation and Experimentation (MOIE) Program.

This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

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REPORT DOCUMENTATION PAGE

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Vibration
Space transportation system

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The SD802 materials experiment has been subjected to a certification vibration test as a ~~STS~~ flight safety completion requirement. The test described within this report verifies the structural integrity and demonstrates the ability to satisfy functional requirements of the experiment. The final flight weight and center of gravity of each experiment tray were also determined.

CONTENTS

FIGURES

FIGURES (Continued)

TABLES

I. BACKGROUND AND SUMMARY

The Long Duration Exposure Facility (LDEF) is a reusable structure designed to accommodate many self-contained experiments during a proposed 9-month exposure in space. The space shuttle will be used to deploy and retrieve LDEF.

The Long Duration Exposure Facility has been developed by the NASA office of Aeronautics and Space Technology and the NASA Langley Research Center (LRC). Through a memorandum of agreement between the Department of Defense (DoD) Space Test Program and NASA, a spacecraft materials experiment, comprised of 19 subexperiments, was integrated by the Materials Sciences Laboratory of The Aerospace Corporation for deployment on the LDEF spacecraft.

In this report the results of the certification vibrational tests, center of gravity and weight measurements required to conform to the LDEF Project Office safety policy, and requirements for payloads using the Space Transportation System (STS) are documented. Tests described herein were conducted by personnel of the System Engineering Division, NASA-LRC and the Materials Sciences Laboratory of The Aerospace Corporation. The test procedure was drafted by Mr. John F. Rogers of NASA-LRC.

Certification vibration tests were performed on the SD802 materials experiment, NASA experiment No. M0003, and the Air Force Geophysics Laboratory (AFGL) cosmic ray detection experiment, NASA experiment No. M0002. The tests were conducted to verify the structural integrity, assembly workmanship, and to demonstrate the ability to satisfy functional requirements of the experiment after it was subjected to such tests. Previous tests have included qualification vibration tests of experiment hardware and electronics and thermal vacuum exposure of the signal conditioning electronics package.[1,2]

II. TEST DESCRIPTION

A. TEST ARTICLES

Flight hardware for the SD802 materials experiment consists of four experiment trays. Each tray is divided into six equal rectangles for convenience in sizing and mounting experiments. Figures 1 and 2 provide tray dimensions for 3- and 6-in. depth trays. Engineering batteries were installed within the trays to accurately simulate the various states of stress concentration and fatigue associated with the placement of a large mass within a structure. Table 1 provides the tray location on the LDEF. Figure 3 shows these tray locations on the LDEF structure; Fig. 4 provides an overview of the basic LDEF structure.

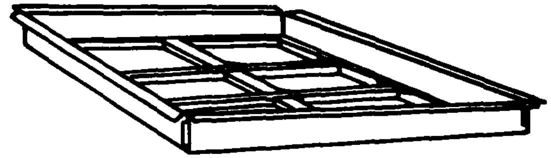
1. EXPERIMENT TRAYS (3 IN. DEPTH)

Both the leading and trailing edge 3-in. trays contain six individual experiment modules. Modules I through IV and Module VI of both trays are similar. Module V leading edge tray contains a fiber optic experiment and electronic plastic encapsulated devices; this module is an electronic active experiment. The trailing edge Module V contains a nonmetallic material and electronic piece part passive experiment. The power supply for the signal conditioning electronics consists of two 12 V batteries that are mounted at the nonexposed base surface of Module I, both trays. The AFGL experiments are located in Module VI, both trays. The leading edge experiment tray is shown in Fig. 5, and trailing edge tray experiment is depicted in Fig. 6.

2. EXPERIMENT TRAYS (6 IN. DEPTH)

Both the leading and trailing edge 6-in. trays contain six individual experiment modules. The contents of both trays are similar but differ slightly in test sample types that are located within Modules III and VI. Modules I and II contain the experiment power and data system (EPDS) and a 7.5 and 12 V battery that supplies power for EPDS. Nonmetallic and metallic composite materials are combined within Module III along with a 7.5 and 28 V battery that powers the Environment Exposure Control Canister (EECC). The

EXPERIMENT SIZE	TRAY SPACE
1/6 TRAY	16.50 x 18.75
1/3 TRAY	16.50 x 37.50
2/3 TRAY	33.00 x 37.50
FULL TRAY	37.50 x 49.50



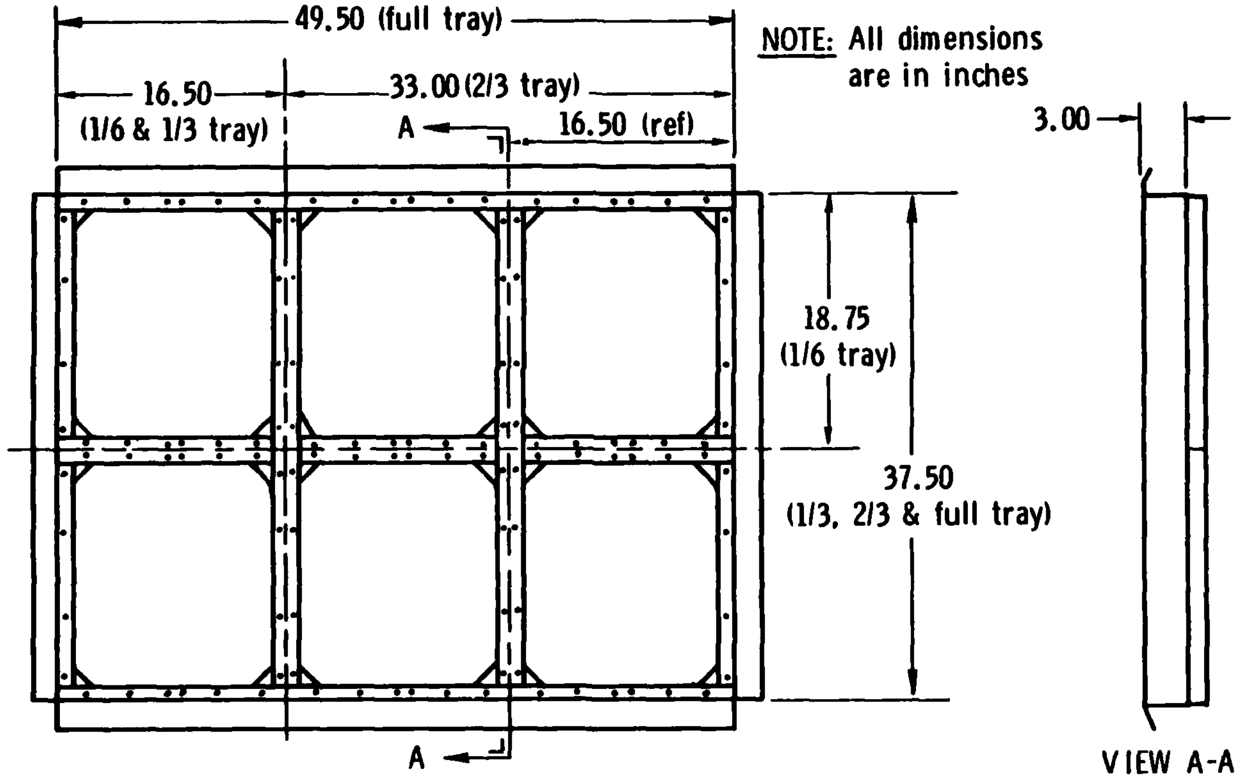
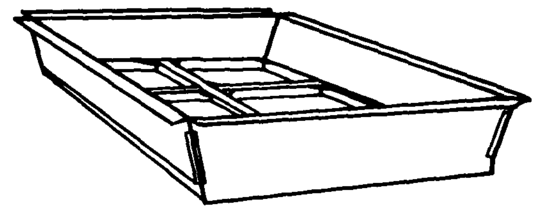


Fig. 1. LDEF Peripheral Tray Assembly, 3-in. Depth

EXPERIMENT SIZE	TRAY SPACE
1/6 TRAY	16.25 x 16.50
1/3 TRAY	16.25 x 33.00
2/3 TRAY	32.50 x 33.00
FULL TRAY	33.00 x 48.75



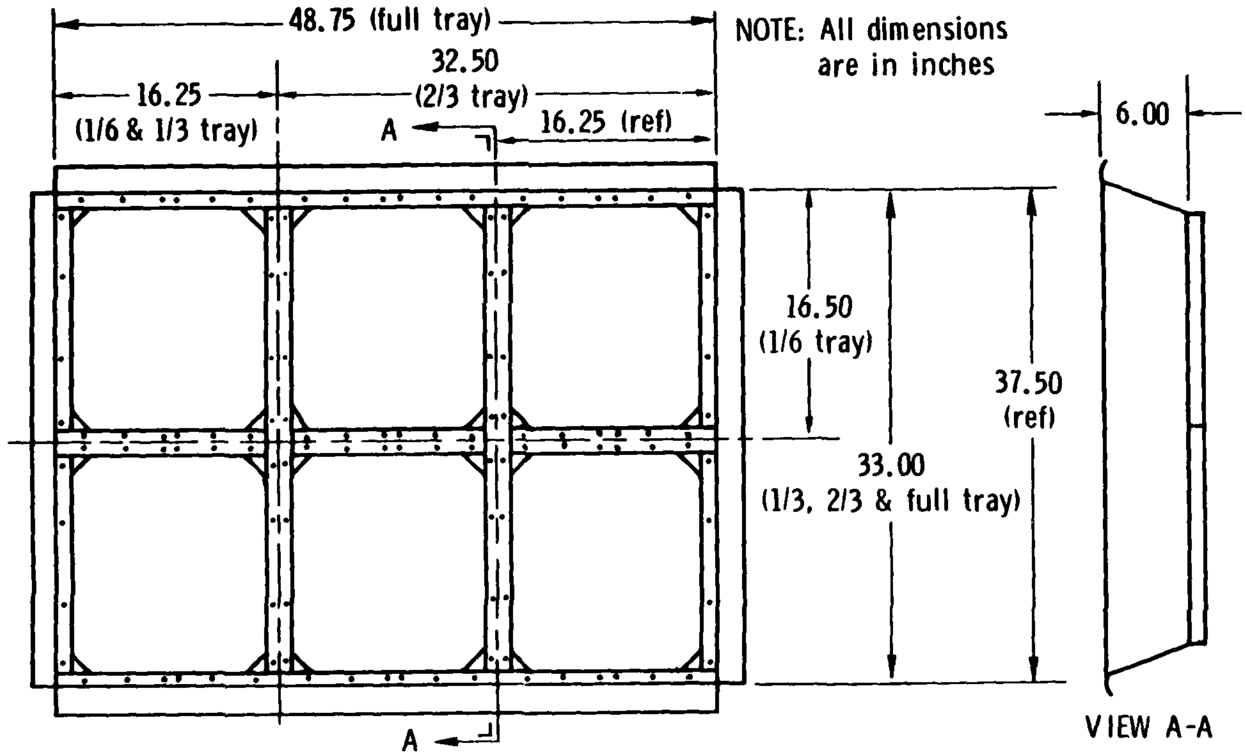


Fig. 2. LDEF Peripheral Tray Assembly, 6-in. Depth

Table 1. Tray Location on LDEF

LDEF Location	Tray S/N	Description
D3	LE 155621-A-1-11	Trailing edge 3-in. depth tray (T3)
D4	LE 155629C-7	Trailing edge 6-in. depth tray (T6)
D8	LE 155629C-10	Leading edge 6-in. depth tray (L6)
D9	LDE 155621A-1-3	Leading edge 3-in. depth tray (L3)

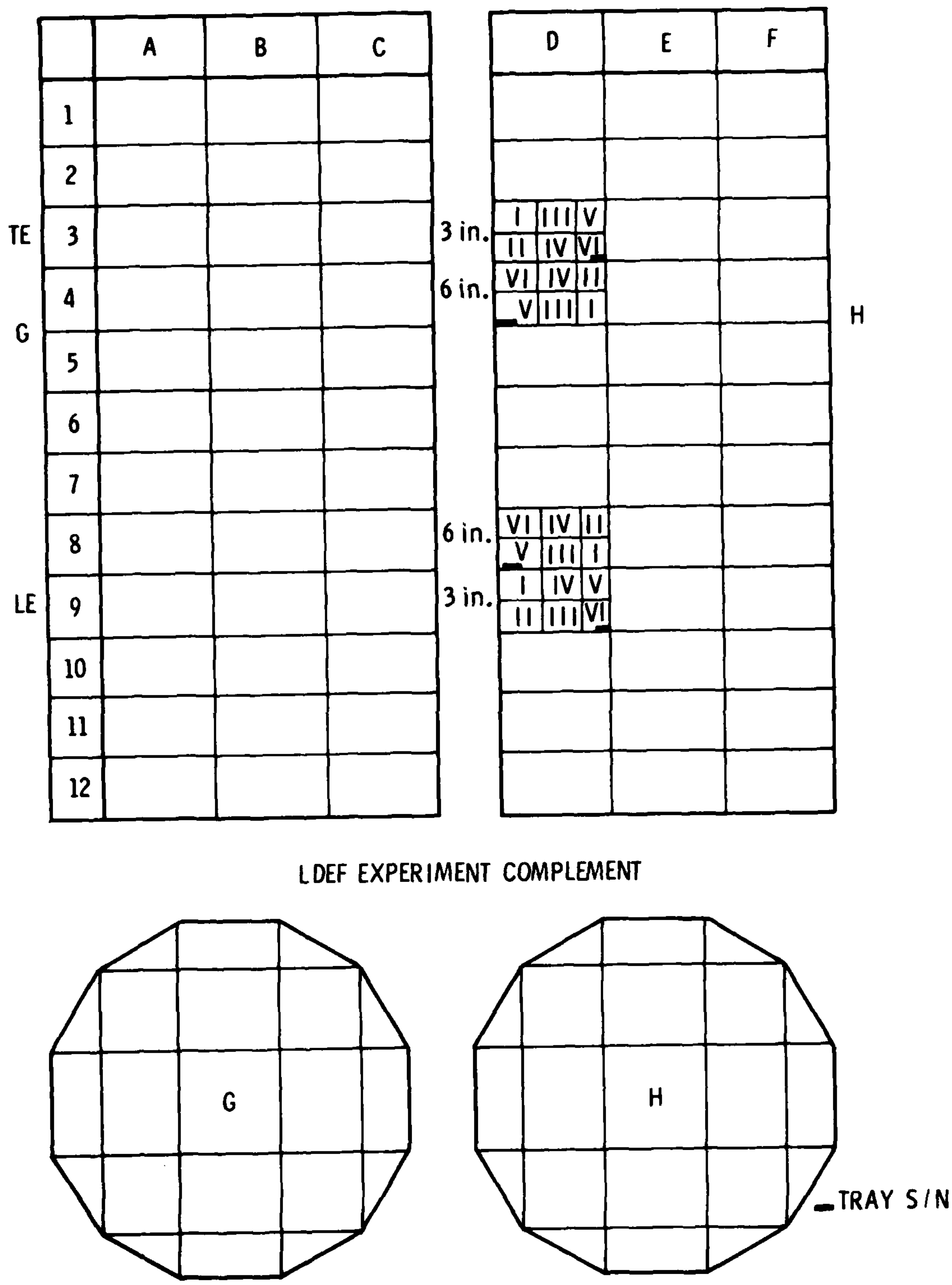


Fig. 3. Tray Location on LDEF Structure

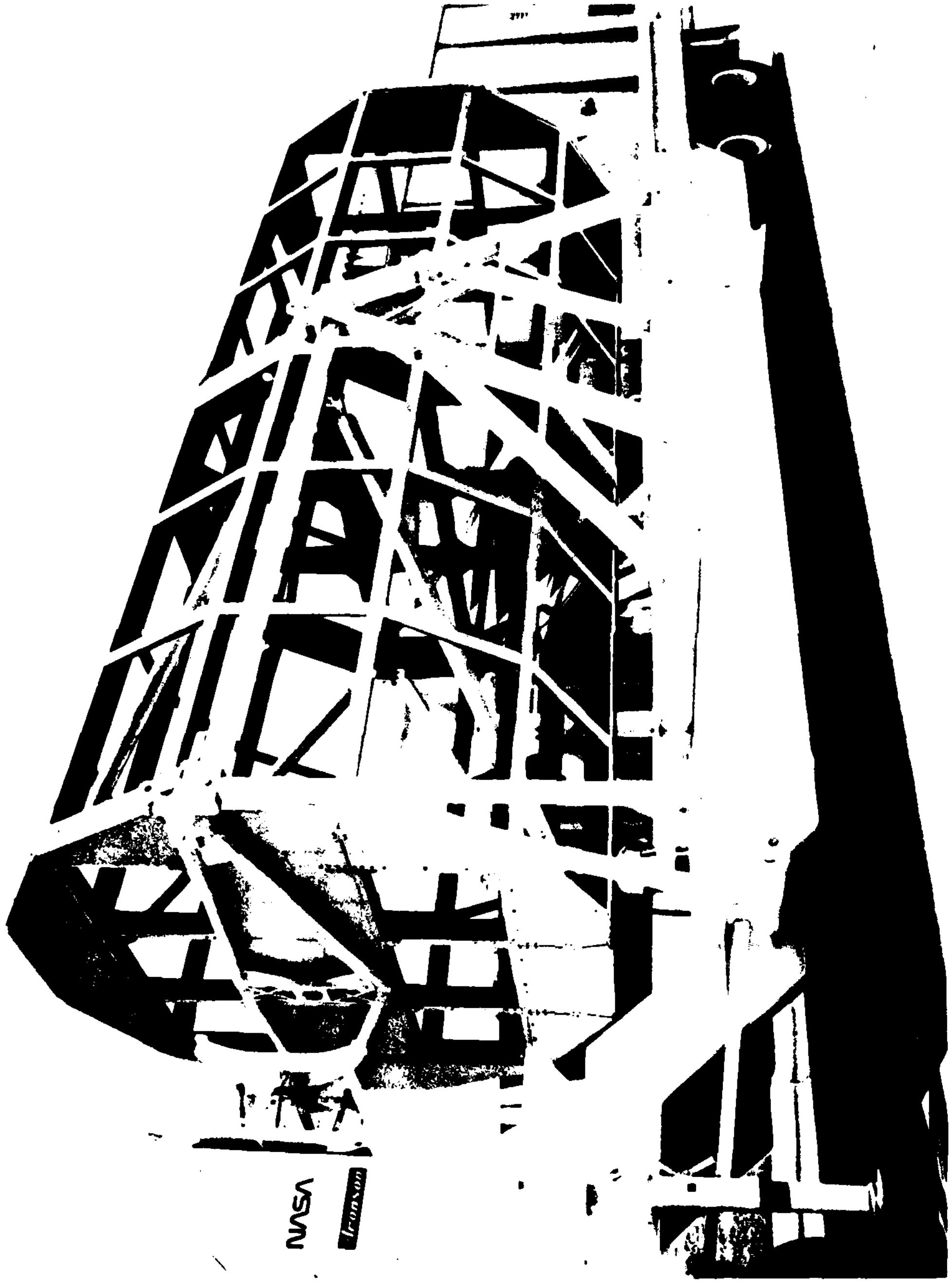


Fig. 4. LDEF, Overview of Structure

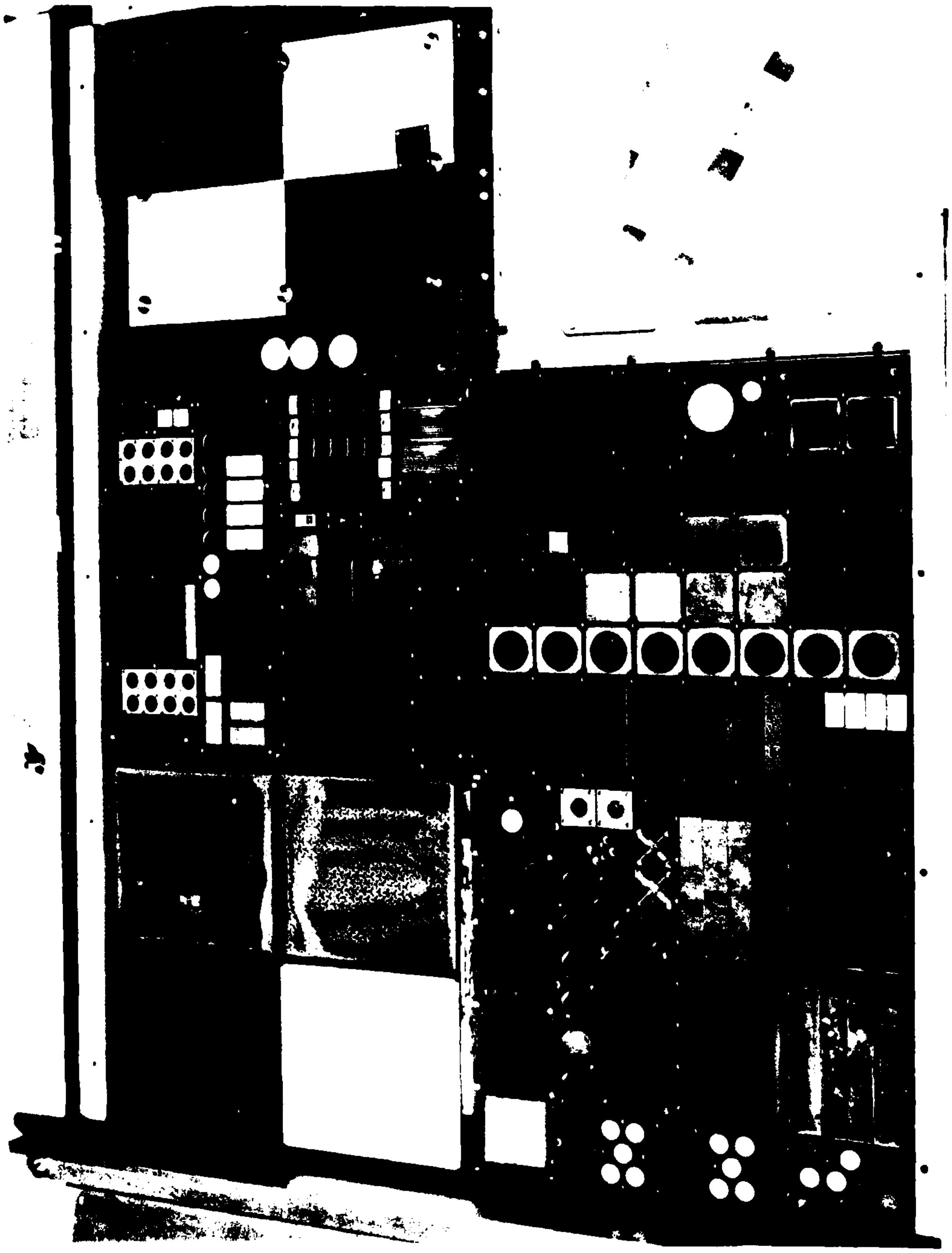


Fig. 5. Leading Edge 3-in. Depth Experiment Tray

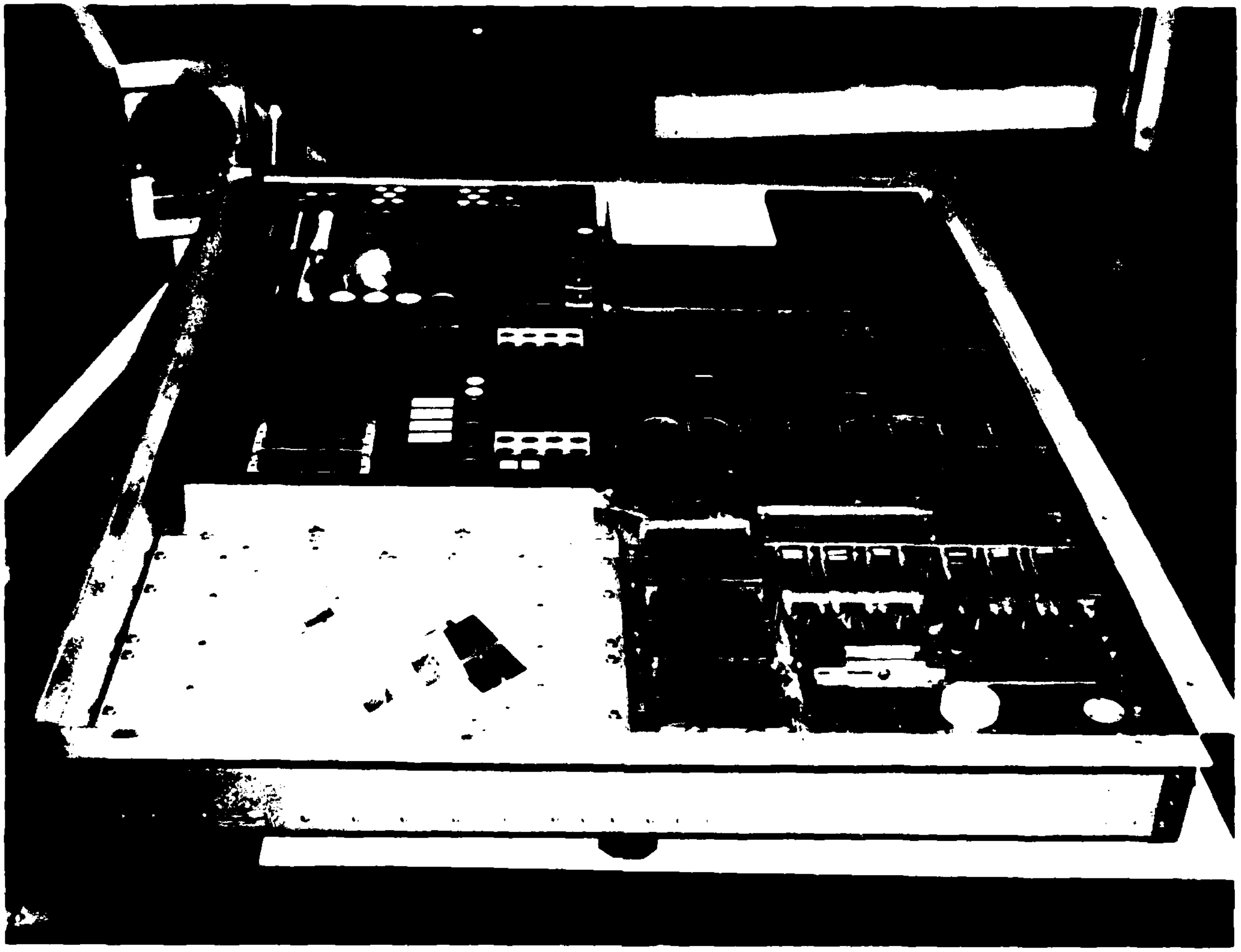


Fig. 6. Trailing Edge 3-in. Depth Experiment Tray

signal conditioning electronics package occupies Module IV, and the EECC occupies Modules V and VI. The trailing edge 6-in. depth experiment tray is shown in Fig. 7. The EECC heat shield is not installed.

3. TEST FIXTURE

The test fixture was manufactured to accommodate testing of 3- and 6-in. depth peripheral experiment trays. The tray to fixture mounting interface was designed to simulate the tray to LDEF structure coupling. Attachment of the tray to the fixture required the use of special shims and a procedure similar to that for attachment to LDEF. The aluminum test fixture weighs approximately 600 lb.

B. TEST FACILITY

1. EXPERIMENT PROCESSING

The sequence of events from receiving inspection to the bonded storage area for experiment processing and preparations at LRC are summarized in Fig. 8. Written procedures were required for all operations; experiment log sheets were maintained to document operations performed; adherence to procedures were monitored by the NASA Quality Assurance unit. A brief summary of the activity of each station follows. The procedure used for electronic functional tests is presented in Appendix A.

2. RECEIVING INSPECTION

The LRC receiving dock is the arrival point for all experiments. The experiments remain within their container at this facility and were inspected for exterior physical damage only.

3. LAMINAR FLOW CLEAN ROOM

a. Inspection

The laminar flow clean room is maintained at a cleanliness level of 100,000. The air flow within the room is from end to end. Within the laminar flow room the shipping container cover is removed and the interior of the container, exterior of the experiment, and the silica gel desiccant were inspected. The aluminum protective cover attached to each experiment tray was not removed at this time. In Fig. 9 is shown a photograph taken during this inspection. Upon completion of this examination the experiments were returned to the bonded storage area.

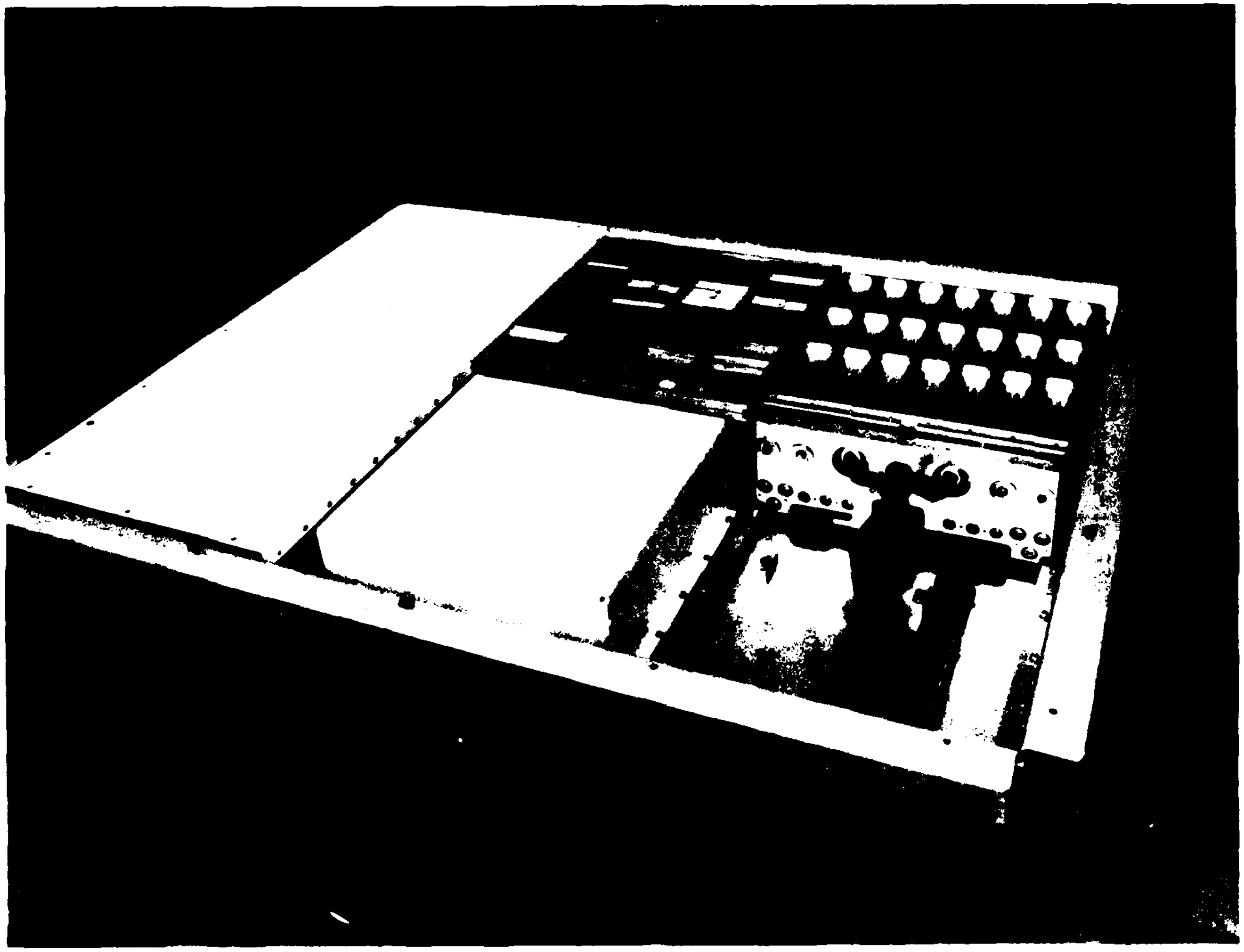


Fig. 7. Trailing Edge 6-in. Depth Experiment Tray

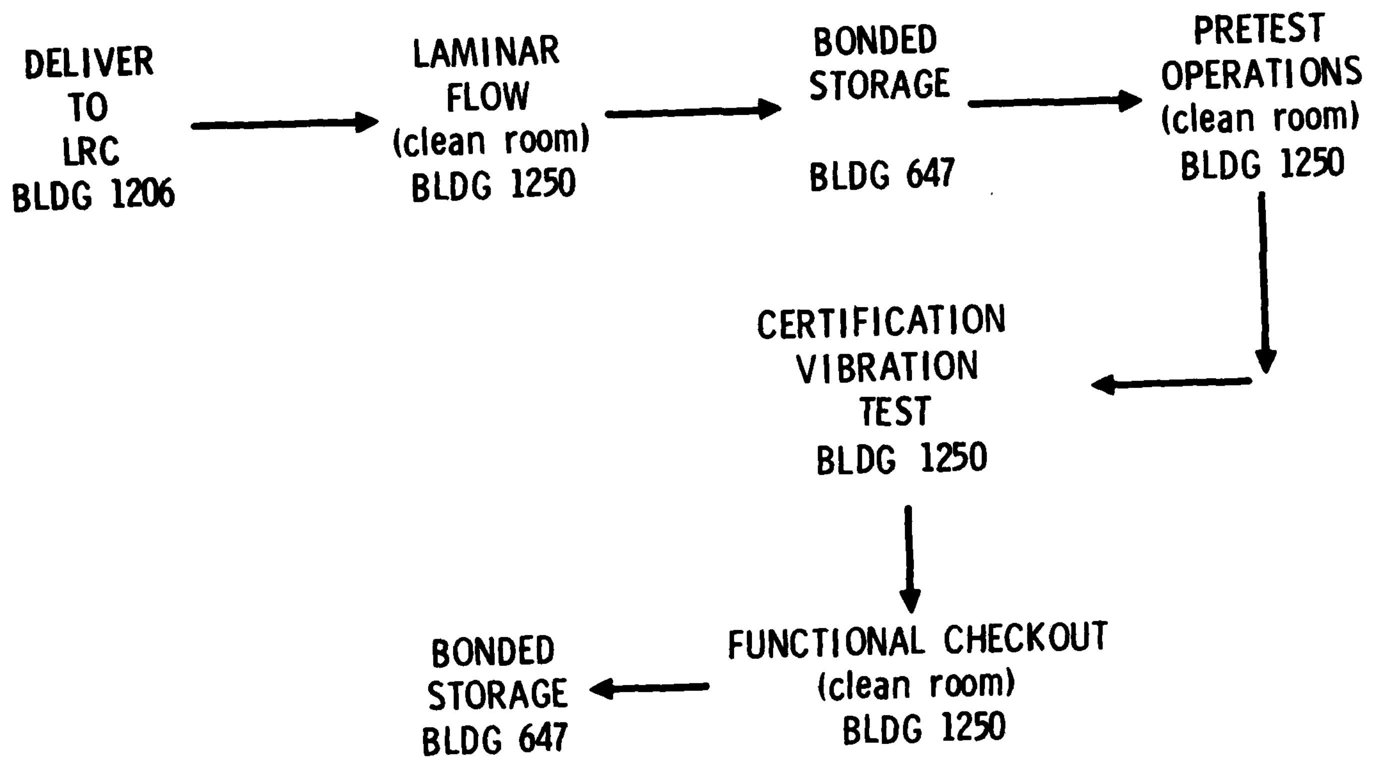


Fig. 8. Experiment Processing and Preparation

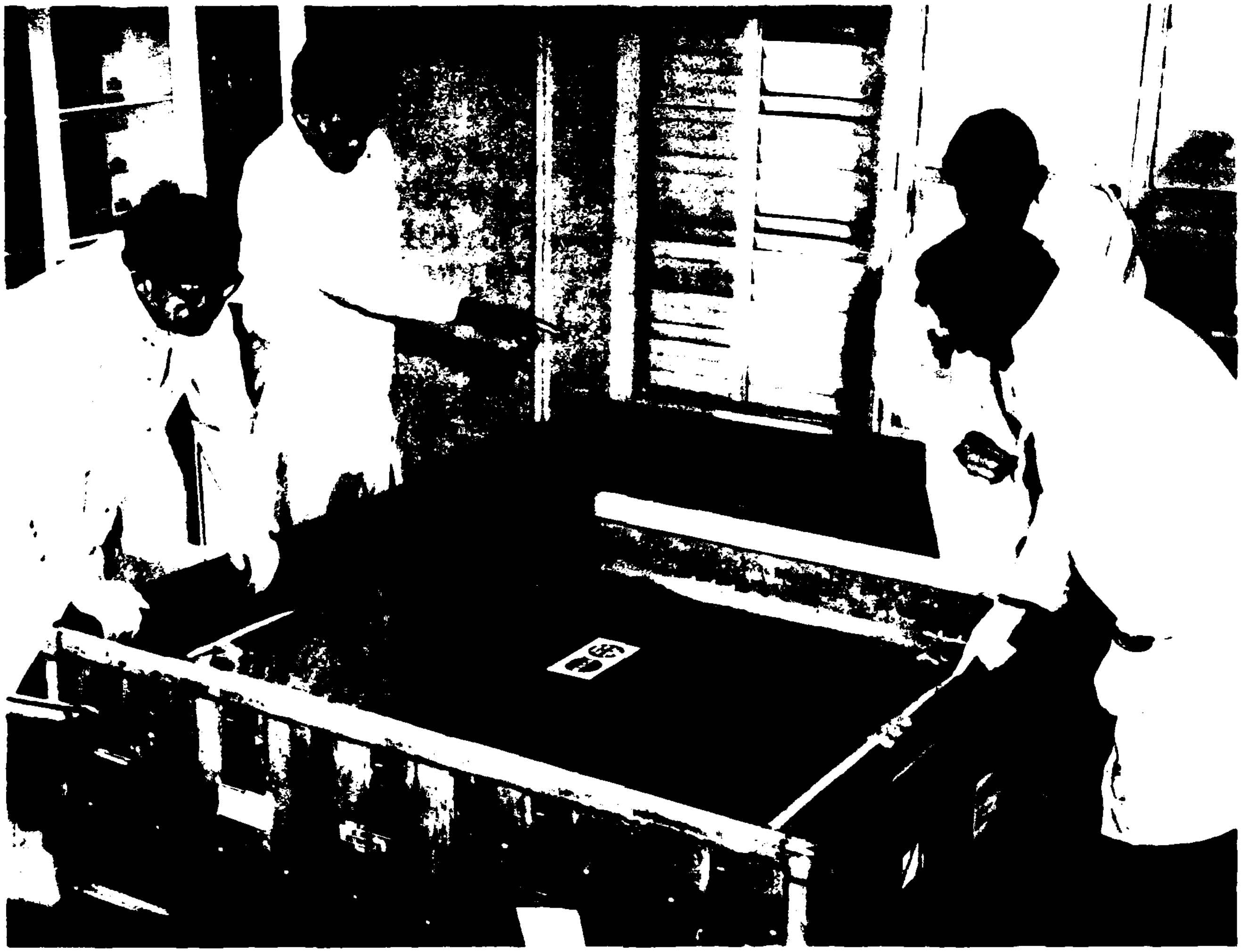


Fig. 9. Receiving Inspection, Laminar Flow Clean Room

b. Operations

When the experimenters arrive at LRC, the experiments are returned to the laminar flow clean room and prepared for electronic functional tests. The following steps summarize the activity within the laminar flow room:

1. Postshipment, premodification, electronic functional tests

2. EPDS modification and removal of EPDS magnetic tape recorder

3. Postmodification and precertification vibration electronic functional tests

4. Postcertification vibration electronic functional tests

5. Preparation of experiments for storage

4. BONDED STORAGE AREA, BUILDING 647

This is a controlled number access area; items are logged in and out by Quality Assurance personnel and moved only by written request. The following environment is maintained:

Temperature	40 to 90°F Heat and air conditioning
Humidity	Less than 60% relative
Cleanliness	Similar to office space (experiment remains in shipping container)

5. VIBRATION FACILITY, BUILDING 1250

This room is not maintained as a clean room, but every effort is made to assure that clean room practices are adhered to; through traffic is minimized, and the use of polyethelene protective covers is extensive. Temperature is maintained between 40 to 90°F, humidity < 60% relative. Floor space within this area is also provided to accommodate the weight and center of gravity test set up. This test arrangement is shown in Fig. 10.

a. Vibration Equipment

A description of the equipment used for vibration testing is as follows:

One Unholtz-Dickie T1000 electrodynamic shaker with self-contained slip table and T145 amplifier

Fig. 10. Vibration, Weight, and CG Test Area in Building 1250

- 17,500 force lb, peak sine capability
- 14,000 force lb, random RMS capability (34,000 LBF peak instantaneous)

Two H-P 5427A digital vibration controller/analyzers

- 4 channel control capability
- Controls sine, random, or shock
- 512 line resolution for random or shock
- Floppy disk program and data storage
- Tabular or graphic hard copy data output
- Extensive analysis capability

Fourteen channel analog tape recorder/playback with digimark and voice annotation

C. PROCEDURE

1. VIBRATION

Each experiment tray was subjected to the following vibratory sequences: (1) transfer function determination, (2) self-check signal determination, (3) sinusoidal vibration test, and (4) random vibration test. Individual test procedures were provided for each of the four experiment trays. Again, verification of adherence to the test procedure was documented by Quality Assurance personnel. A copy of the Experiment Certification Vibration test procedure is provided as Appendix B. A copy of each completed test procedure is on file at the Materials Sciences Laboratory of The Aerospace Corporation and the LDEF Project Office at LRC.

The trailing edge 3-in. depth tray was the first unit to be subjected to three axes of vibration tests. A drawing of each axis of vibration is provided in Figs. 11 through 13. A 6-in. depth trailing edge tray followed the 3-in. depth tray. The test sequence for the leading edge trays were altered. Both the 3- and 6-in. trays were tested in a given axis to reduce the amount of fixture handling.

a. Transfer Function

To identify unacceptable amplitude excursions that might occur within the frequency range of the test, transfer function plots were obtained and

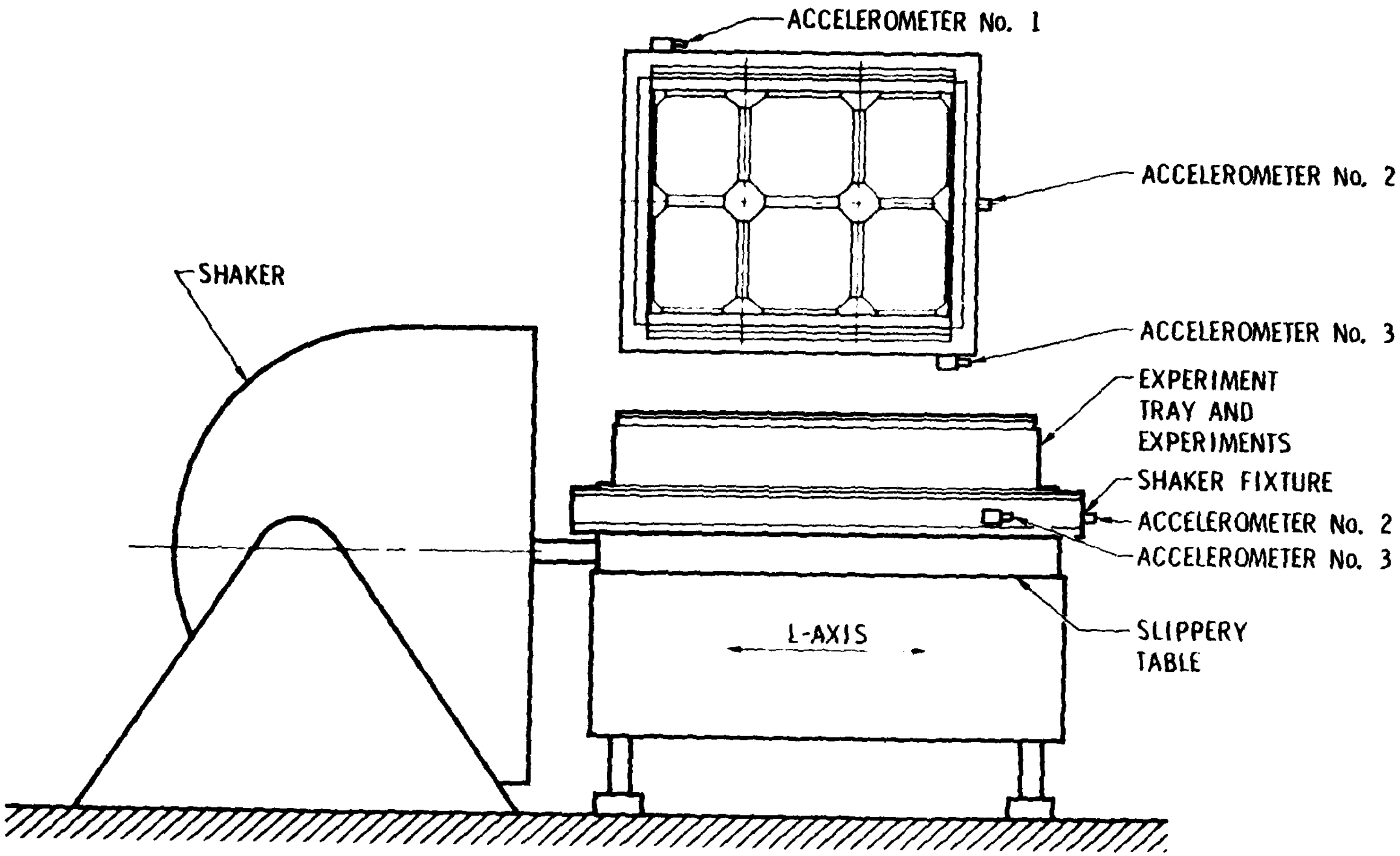


Fig. 11. L-Axis Test Set Up

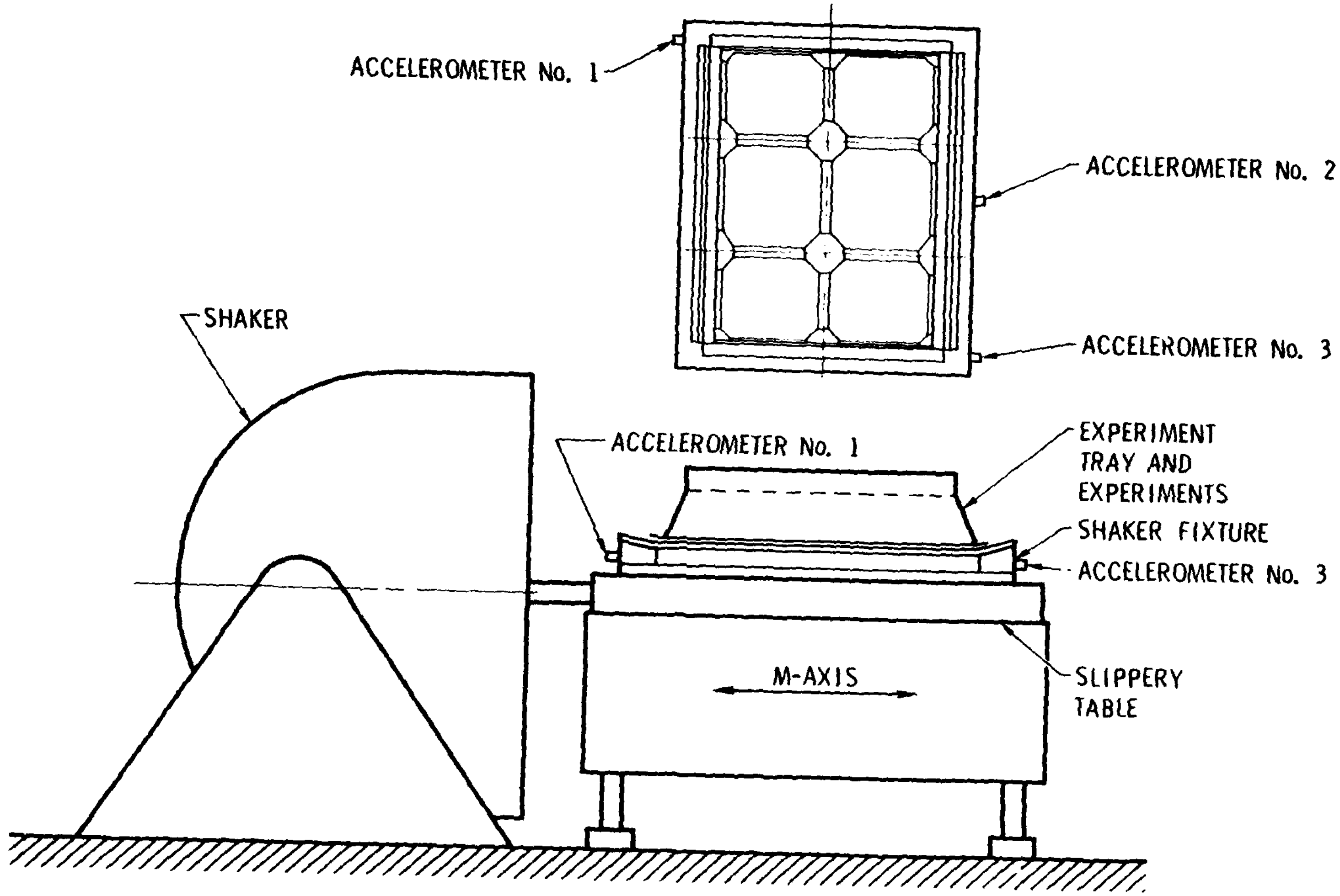


Fig. 12. M-Axis Test Set Up

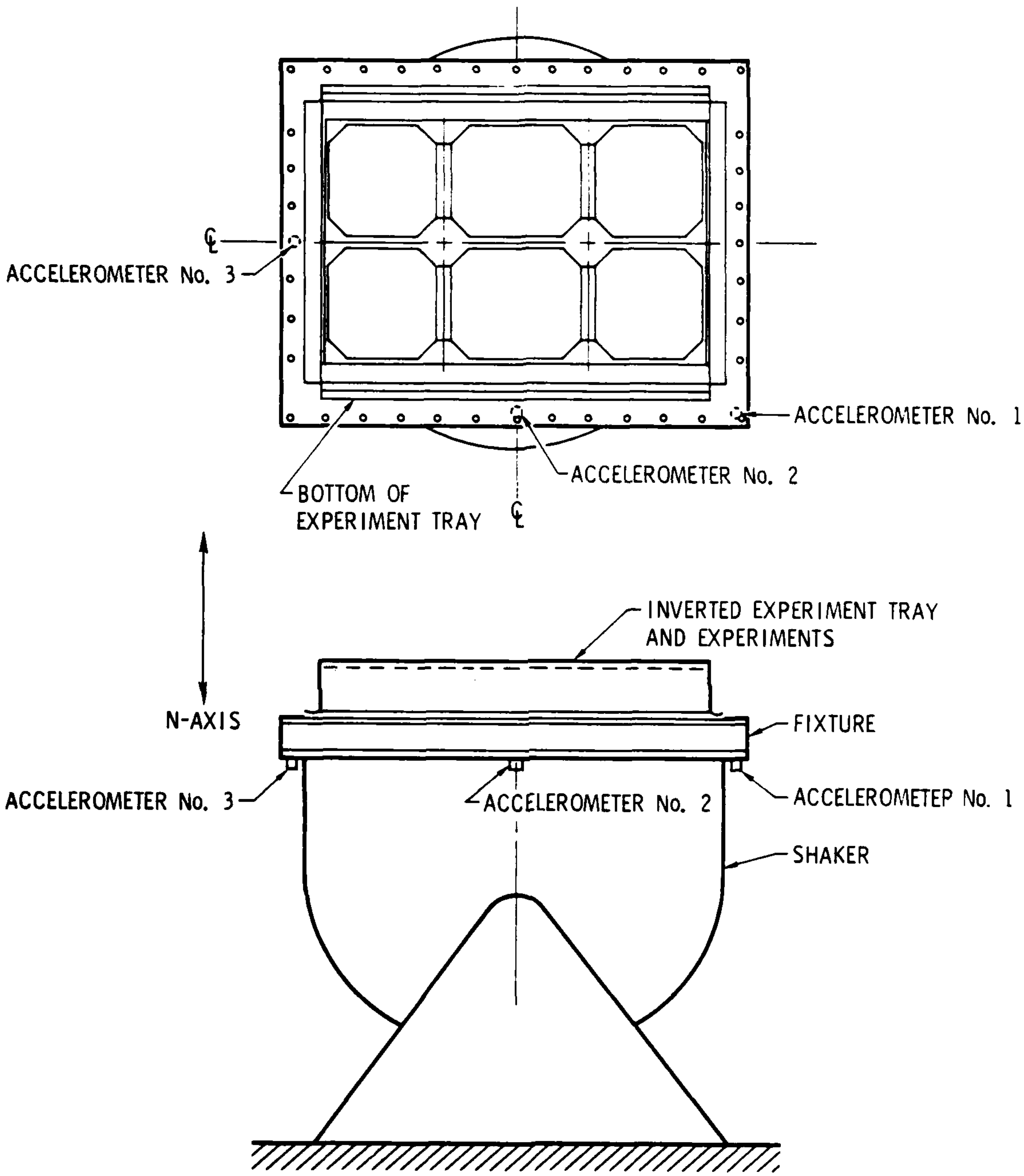


Fig. 13. N-Axis Test Set Up

reviewed prior to progressing with sine and random vibration tests. The vibration system provided the capability of examining the ratio of excitation amplitude and forced vibration by ratioing the output of a control and monitor accelerometer.

Transfer function response test options are as follows:

Bandwith

- 20 to 2000 Hz
- 10 to 100 Hz
- 10 to 50 Hz

Amplitude > 1 g < 2 g pk

Duration 30 to 50 sec

b. Self-Check Signal

The purpose of the control system is to maintain the acceleration at predetermined levels independent of the response of the structure. To assure that the system has the proper signal-to-noise ratio to maintain the system gain, a self-check signal is run, and the drive display is viewed prior to each test. The self-check signal is a pseudorandom signal having the spectral shape of the user-specified reference spectrum. When the self-check signal is applied to the system, the response is measured, and from this the "System Gain" is computed. To avoid overtesting, the self-check signal was applied at approximately -12 dB for a time duration of 10 to 20 sec.

c. Sine Vibration Certification

Test levels for the sine vibration vary both as a function of tray location and tray size. The frequency sweep for all sine tests starts at 35 Hz and sweep down to 16 Hz. The down sweep was used to eliminate equipment overload problems. The frequency sweep test level is shown as follows:

Input Amplitude	Frequency Range	Sweep Rate
1.4 g rms	35 to 20 Hz	4 oct/min
5 to 10.6 g rms	20 to 16 Hz	4 oct/min

A graphic representation of the test levels for the 3-in. depth experiment trays is shown in Fig. 14. The 6-in. depth tray test levels are shown in Fig. 15. An overview of the experiment tray location on the LDEF structure versus the sine vibration test levels is shown in Table 2.

d. Random Vibration Certification

The random vibration frequency spectrum and input test level are identical for all the experiment trays. They are as follows:

1. +3 dB/oct between 20 and 80 Hz
2. ±3 dB/oct between 80 and 350 Hz
3. -3 dB/oct between 350 and 2000 Hz
4. Overall test level 6.1 g rms
5. Test duration 30 sec

A graphic representation is shown in Fig. 16.

2. INSTRUMENTATION

a. Accelerometers

Preliminary vibration tests in each of the three mutually perpendicular axis of vibration were conducted using the tray vibration fixture, NASA No. LE 155606C, and a 3-in. depth experiment tray loaded with a dummy mass to simulate experiments. The purpose of these tests was to determine whether single or multiple point accelerometer control would be required to stay within the bounds of the input specifications. A survey of the accelerometer response data revealed that a single-input control accelerometer could be used for the sine vibration tests. A three point accelerometer input control would be best suited to control the random vibration test spectrum.

Since all the experiment trays were tested in an inverted position, it was impractical to record response data from each experiment module within the tray. A decision was made to limit the number of accelerometer channels to six. Table 3 identifies the accelerometer function, and Figs. 11, 12, and 13 depict the approximate placement of the control accelerometers. Location of the three monitor accelerometers on the 3- and 6-in. depth experiment trays

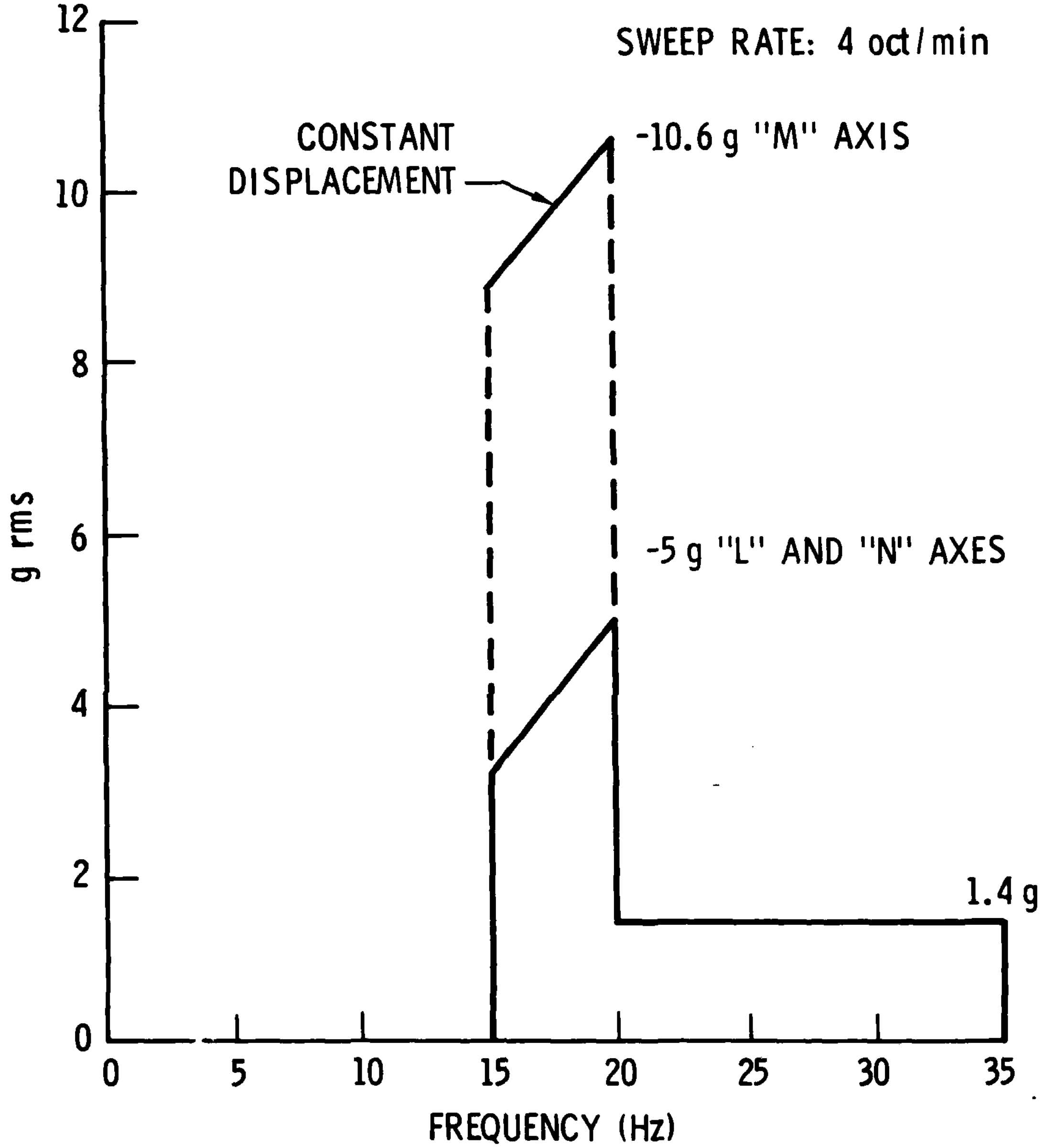


Fig. 14. Sine Vibration Spectrum, 3-in. Depth Experiment Trays, Locations D3 and D9

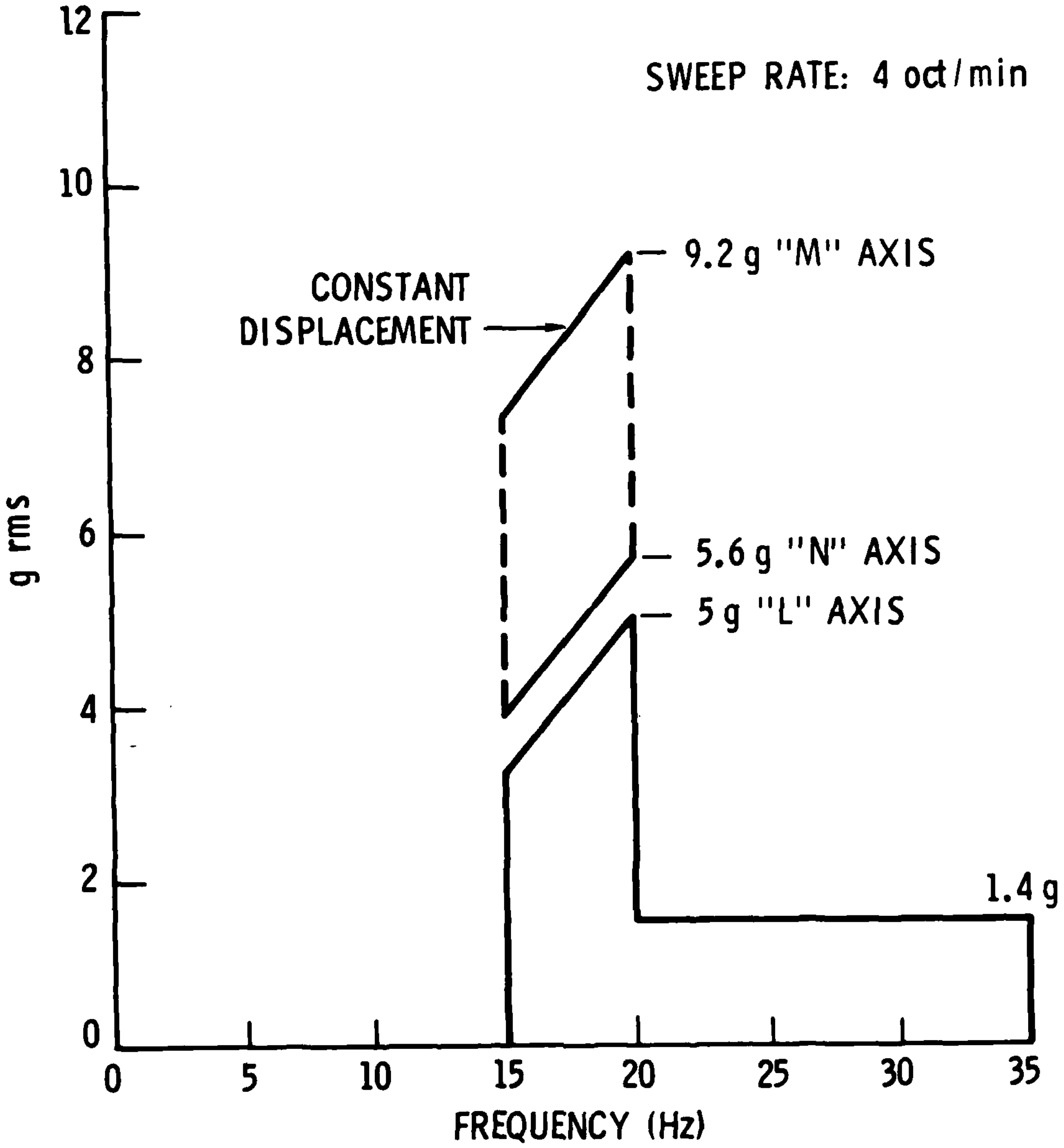


Fig. 15. Sine Vibration Spectrum, 6-in. Depth Experiment Tray, Locations D4 and D8

Table 2. Sine Vibration Test Levels Versus LDEF Structure Location

Experiment No.	LDEF Structure Location	Sine Test Levels (g rms) L	M	N
M0003	D4, D8	5.0	9.2	5.6
M0002 and M0003	D3, D9	5.0	10.6	5.0

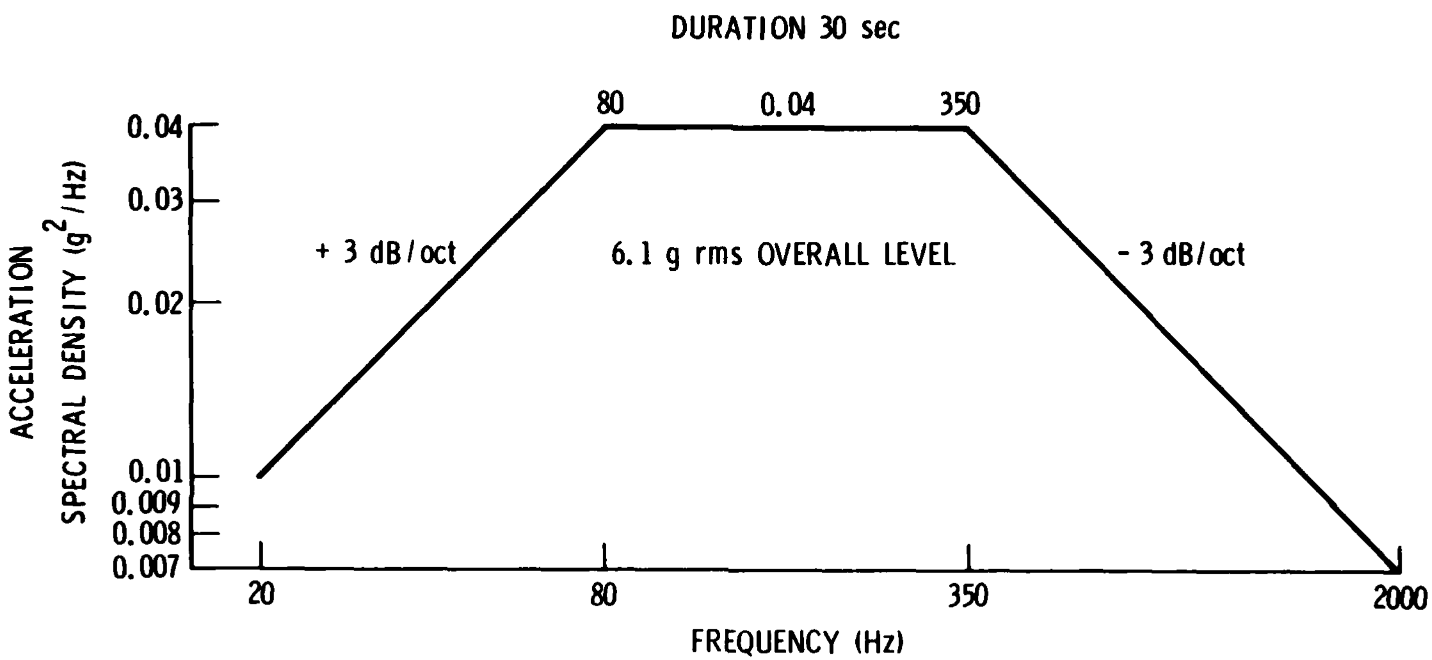


Fig. 16. Random Vibration Spectrum for Certification Acceptance

Table 3. Accelerometer Function

Accelerometer No.	Control		Monitor	Description
	Sine	Random		
1	X	X		Sine drive accelerometer, averaged for random vibration
2		X	X	Monitors fixture during sine test, averaged for random vibration
3		X	X	Monitors fixture during sine test, averaged for random vibration
4			X	Always placed on main I beam of tray
5			X	L3, Module IV, base T3, Module III,base LT6, Module IV, base (SCU)
6			X	LT3, Module I, battery attach plate LT6, Module III, battery attach plate

are shown in Figs. 17 and 18. The monitor accelerometers were removed and remounted for each axis of testing, and the sensitive axis of the accelerometer was oriented to the axis of applied vibration. Actual location of the accelerometer placement may vary from the coordinate points by ±0.25 in.

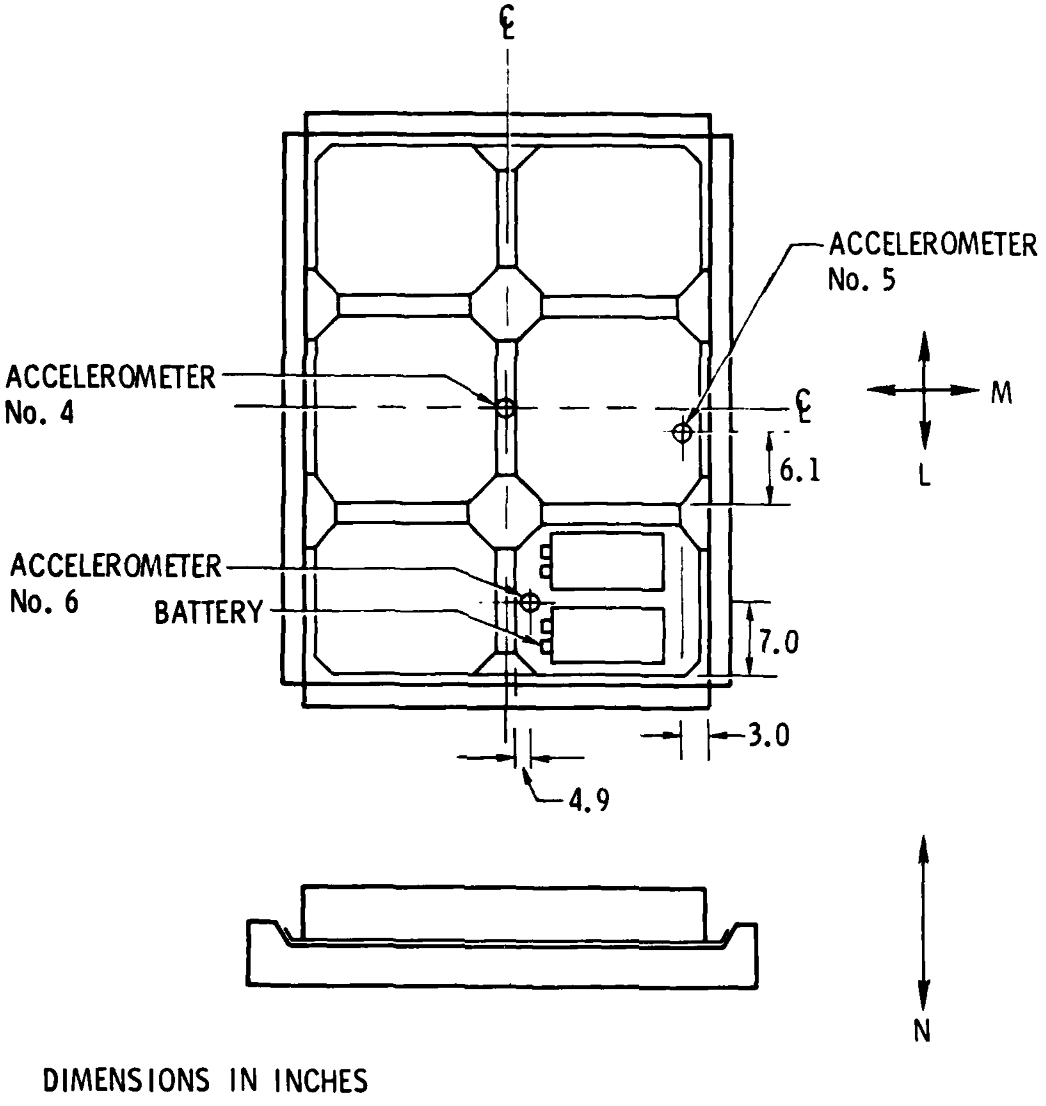
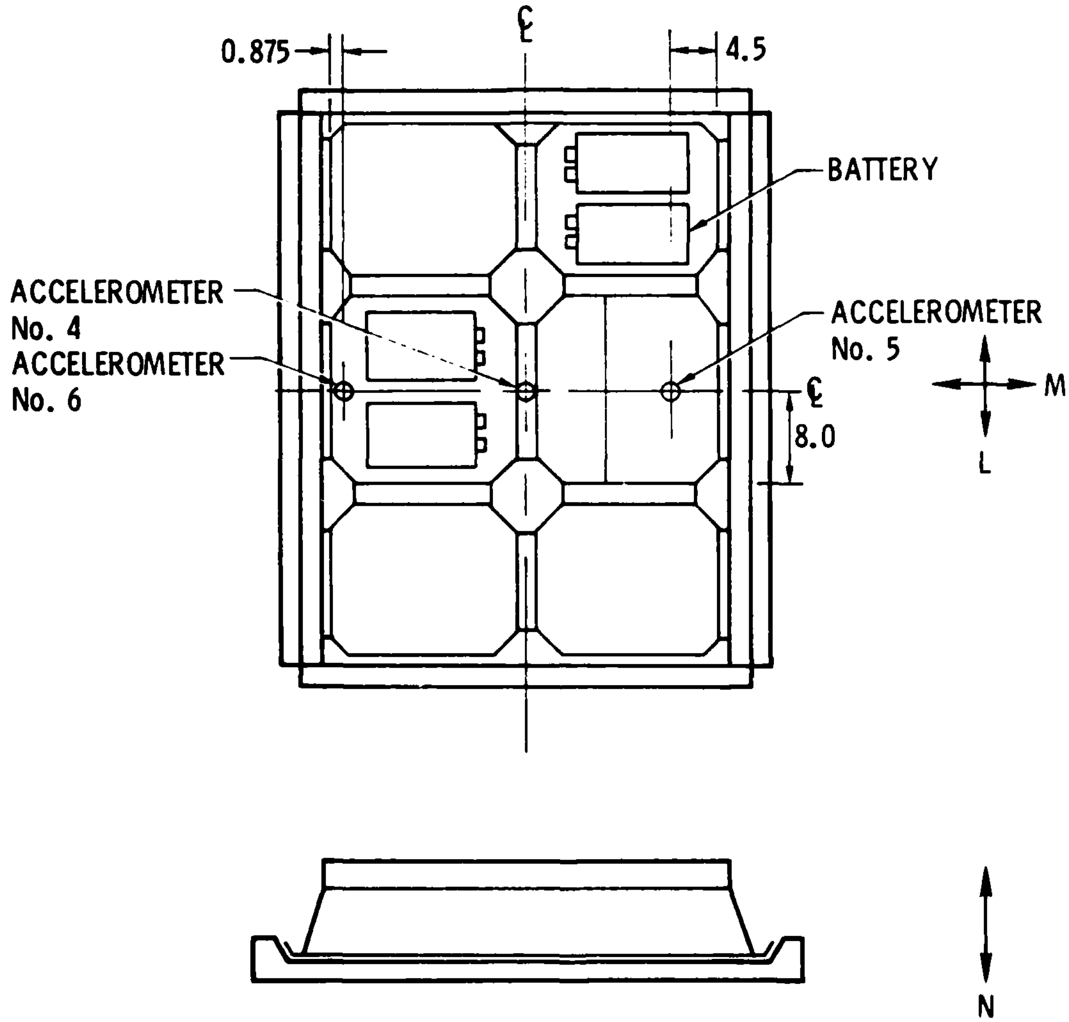


Fig. 17. Monitor Accelerometer Location for the 3-in. Depth Experiment Tray



DIMENSIONS IN INCHES

Fig. 18. Monitor Accelerometer Location for the 6-in. Depth Experiment Tray

III. TEST RESULTS

A. OVERVIEW

Four experiment trays were subjected to the certification vibration tests. No physical structural damage was detected on the tray structure or to the module hardware that retained the test samples. Two test samples, EA3-5 and EA3-7 passive hybrid circuits, debonded during the random vibration test L axis. These test samples were mounted within Module V, 3-in. trailing edge tray. After visual examination of the test samples, the cause of the bond failure was evident. The existing bond covered less than 50% of the bondable area on both test samples. By mutual agreement of the project personnel involved, it was decided to rebond the test samples and not retest in the L axis, but continue testing in the M axis. The amplitude of the sine test is double for the M axis test as compared with the L axis. Random vibration test levels were the same for all axes.

After completing the vibration tests, the data collection and data storage system of tray pairs were exercised using battery power. All data channels and the EPDS timing sequence functioned properly.

B. TRAILING EDGE TRAY (3-IN.)

The N-axis of vibration was first completed. This axis of vibration in respect to all the experiment trays is the most severe from the standpoint of controlling fixture-induced resonant conditions. The test fixture and experiment tray mounted on the vibration exciter in the N axis is shown in Figs. 19 and 20. Note in Fig. 19 that the test fixture extends beyond the vibration exciter head. Transfer function plots are shown in Figs. 21 and 22. The frequency scale on Fig. 22 has been expanded to provide a more detailed look at the low-frequency response.

The ability of the vibration system to control the sine and random input vibration spectrum is shown in Figs. 23 and 24. On both figures the input spectrum curve is flanked by an upper and lower 6 dB boundary. The control accelerometer output is also plotted establishing the system response versus the desired input spectrum.

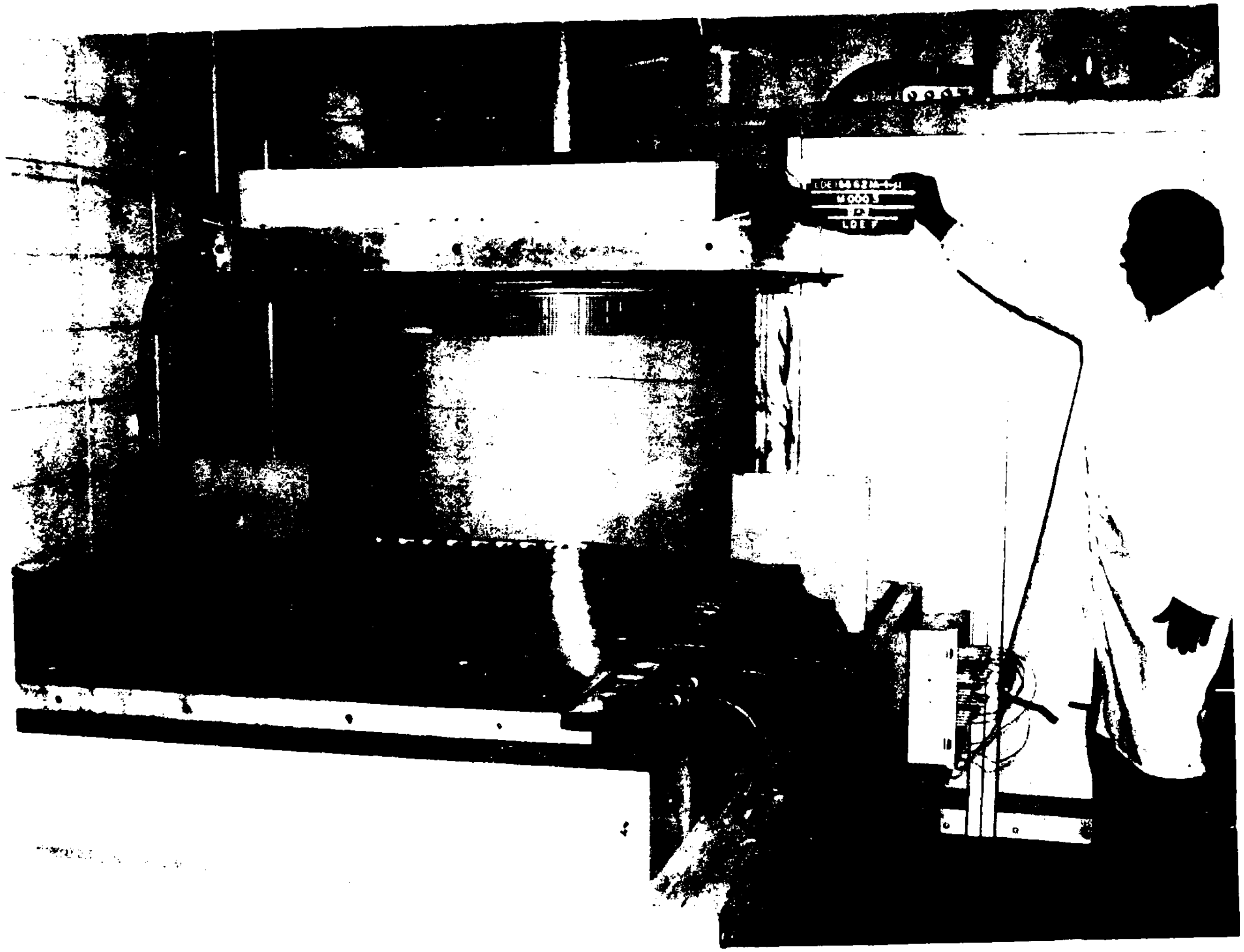


Fig. 19. T3, Experiment Tray, N Axis Test Set Up

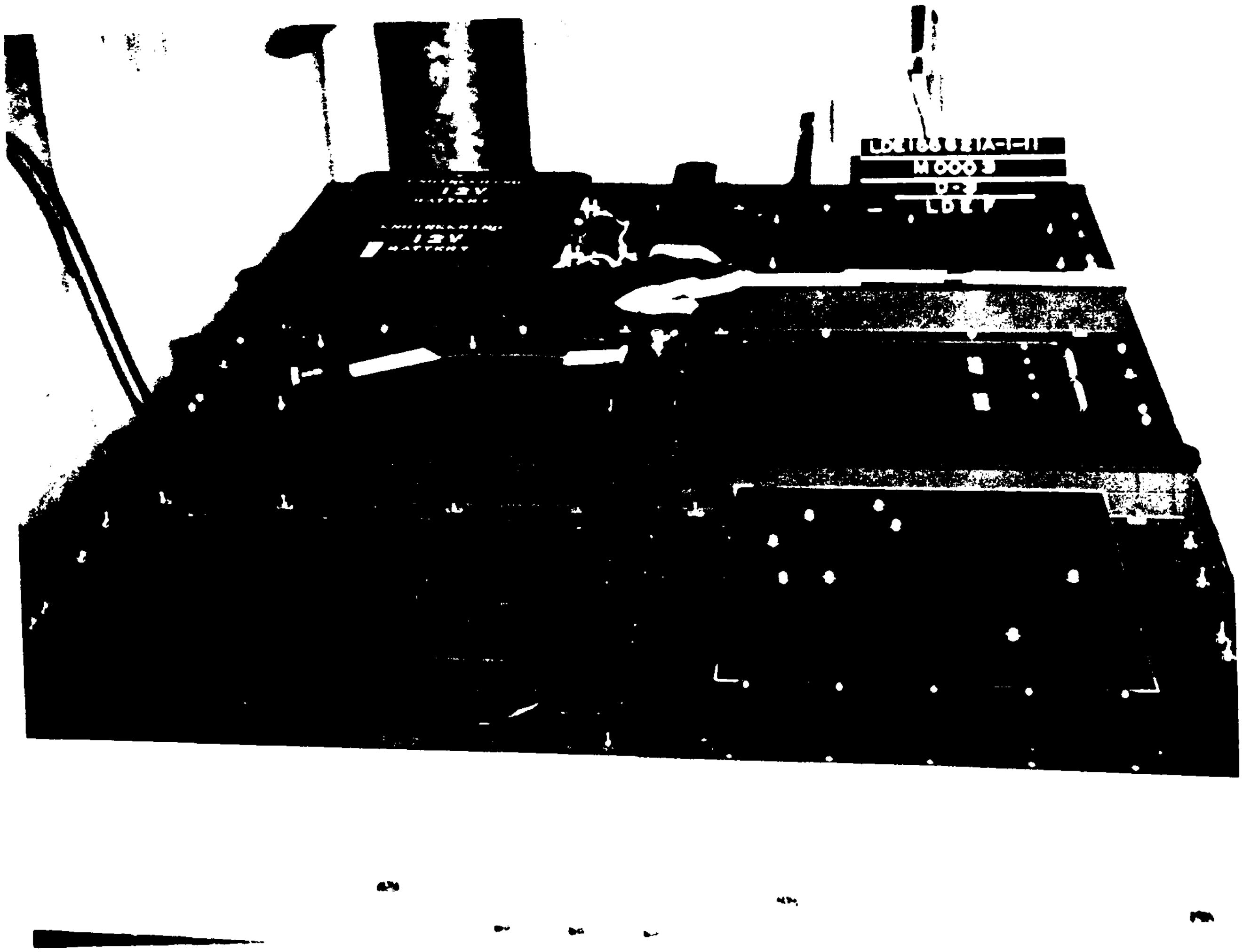


Fig. 20. T3, Experiment Tray, N Axis, Tray Base

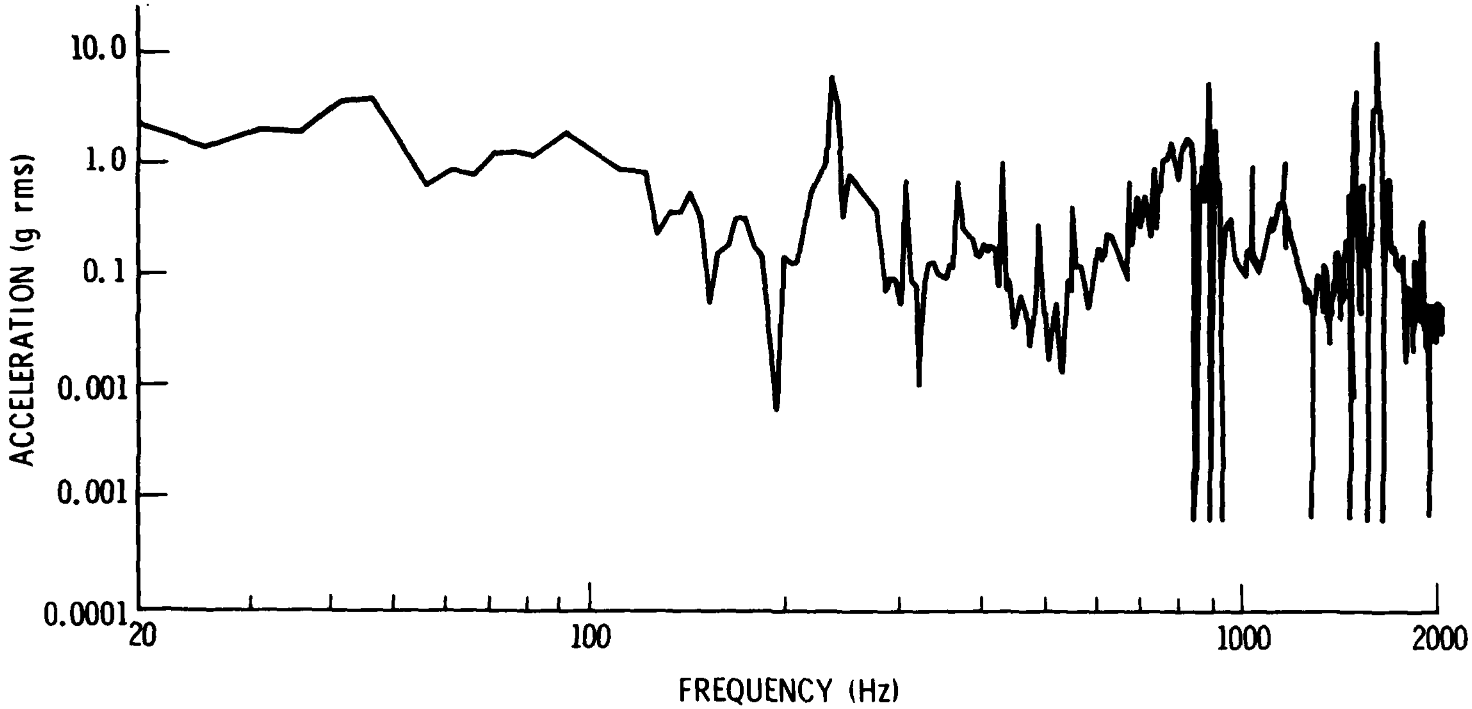


Fig. 21. T3, Transfer Function, N-Axis, 20 to 2 KHz, Accelerometer 4/1

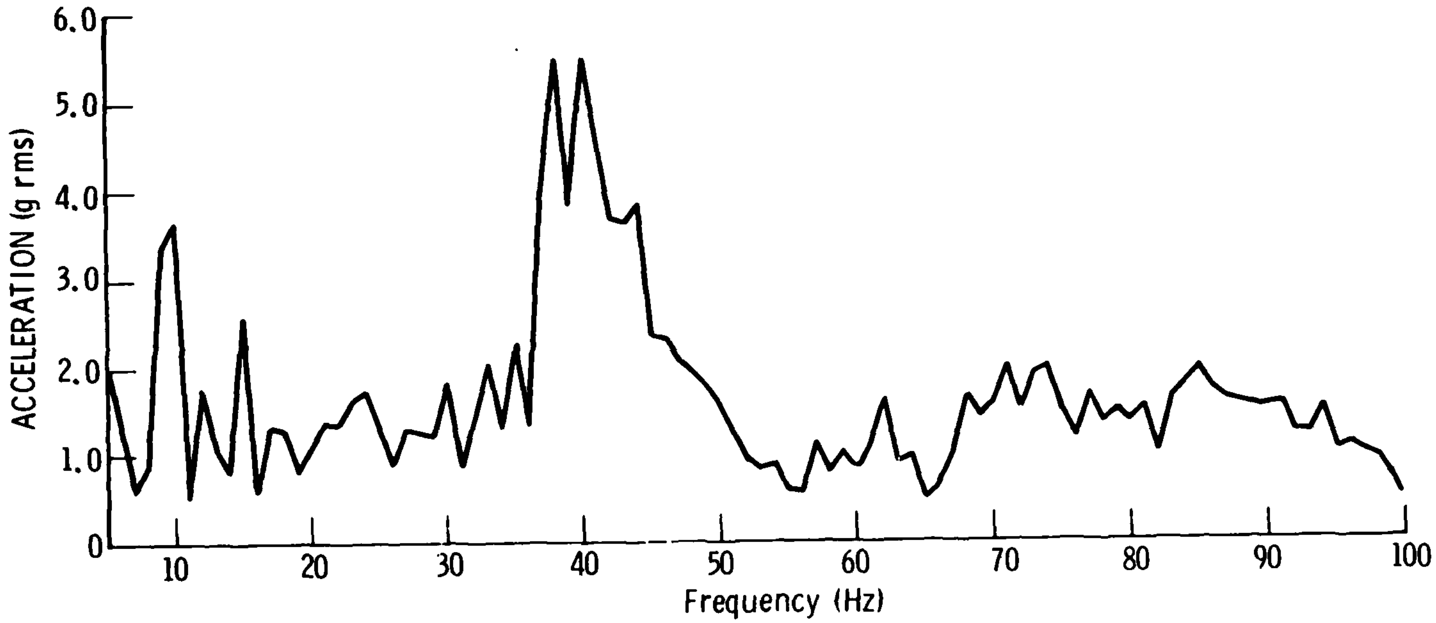


Fig. 22. T3, Transfer Function, N-Axis, 10 to 100 Hz, Accelerometer 4/1

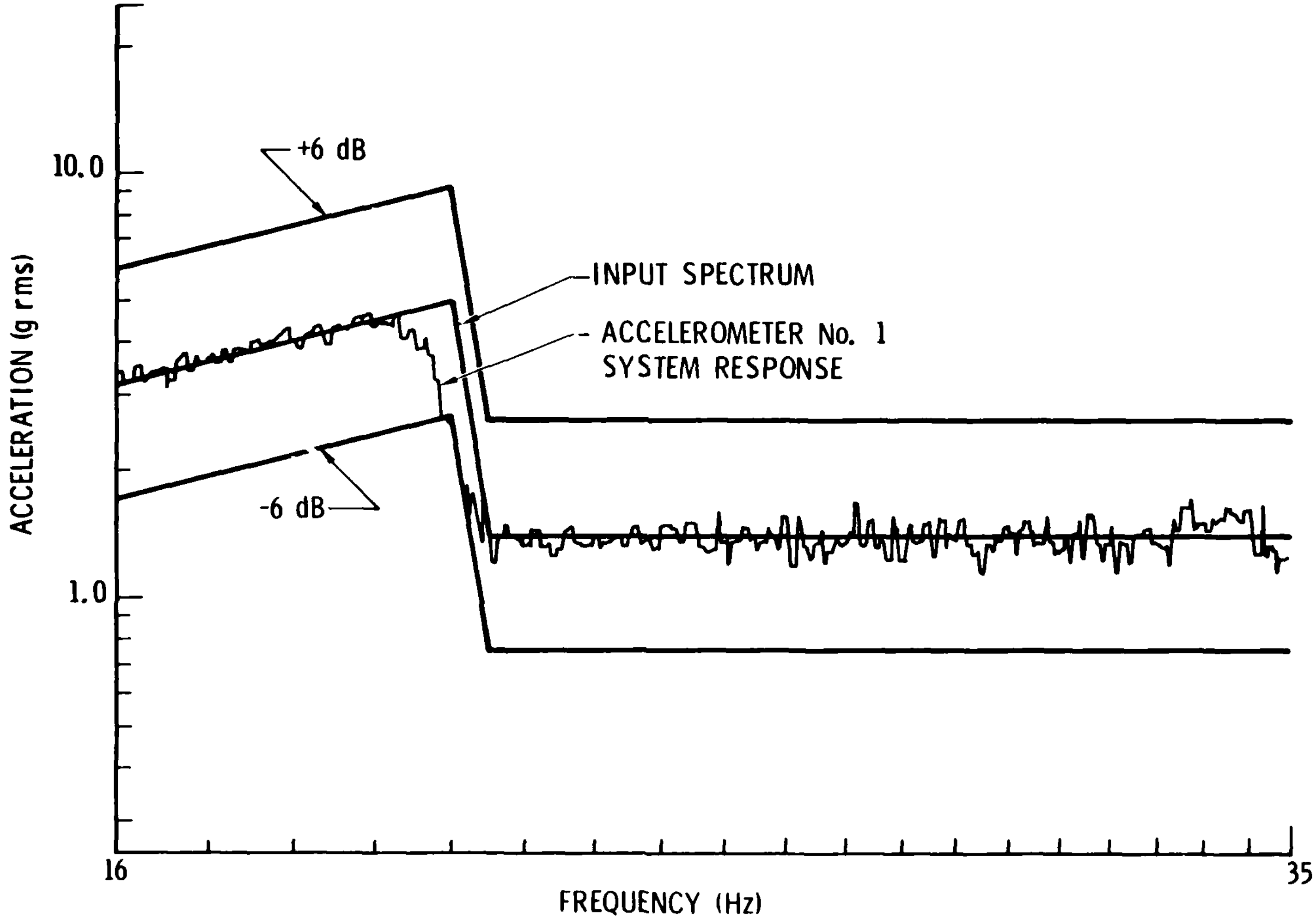


Fig. 23. T3, N-Axis, Sine Certification Input Spectrum, Accelerometer No. 1

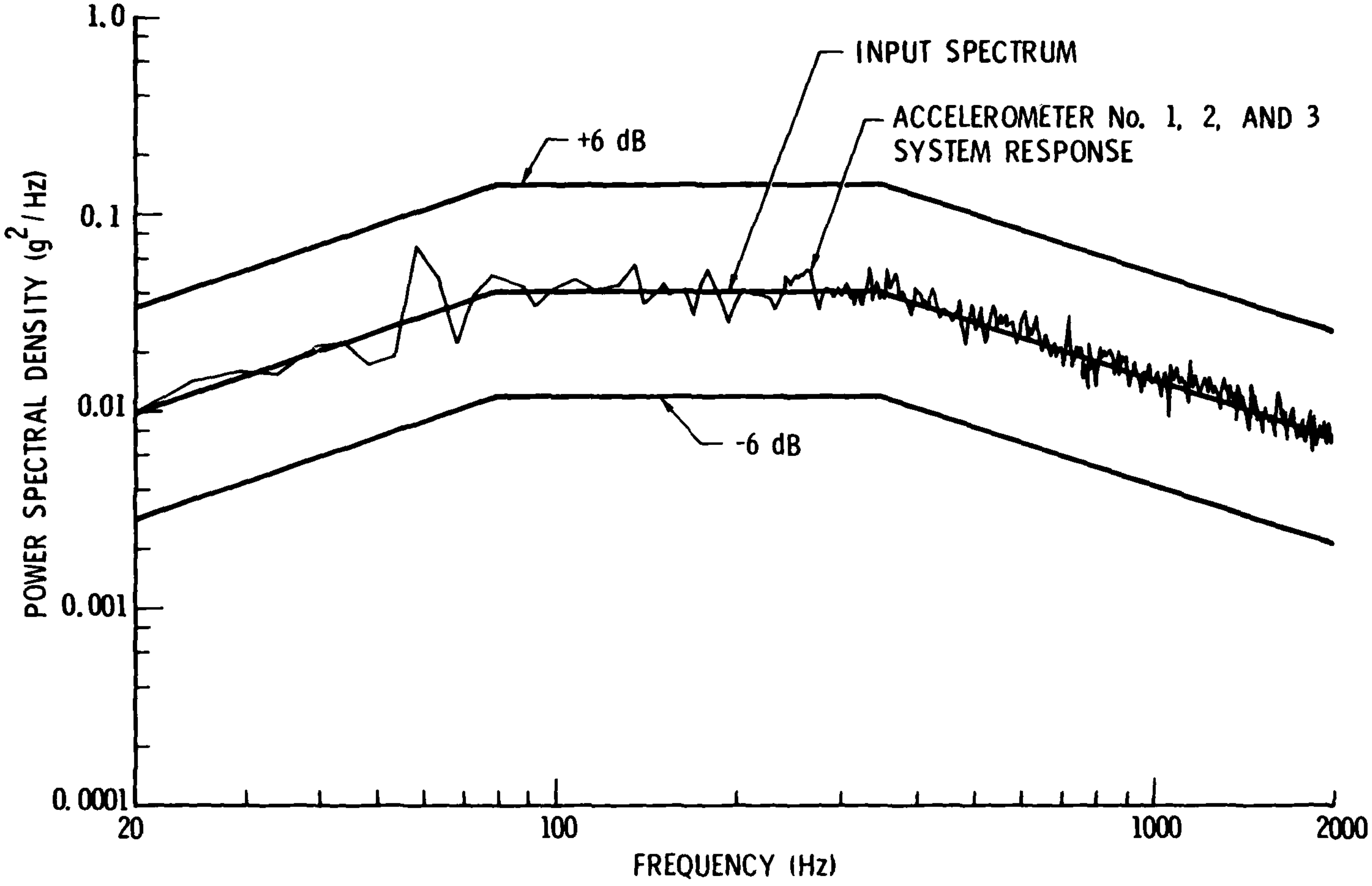


Fig. 24. T3, N-Axis, Random Certification Input Spectrum, Accelerometer No. 1, 2, and 3

Transfer function plots for the L axis of vibration is shown in Figs. 25, 26, and 27. The frequency scale on the plots was again expanded to examine the low-frequency response. These plots indicate that in the frequency band between 15 to 20 Hz, there are no high-Q resonant peaks. Figures 28 and 29 present the output of the sine and random test control accelerometer.

Transfer function plots for the M axis and Figs. 30, 31, and 32 also indicate the absence of high-Q resonant peaks between 15 to 20 Hz. In Figs. 33 and 34 the output of the sine and random test control accelerometers are presented.

C. OTHER TRAY RESPONSE DATA

A review of the input and monitor accelerometer data for the remaining L3, L6, and T6 three experiment trays show similar low amplitude response data for the transfer function plots. For the other trays the specified input spectrum versus the actual drive accelerometer output is also similar to Figs. 33 and 34. The input and monitor accelerometer data for the remaining three trays are presented as Appendix C.

D. DATA RECORDING

1. BACKGROUND

A SD/LDEF Technical Users Manual has been published and provides a complete review of the flight and ground support electronics, programming, qualification testing, and transducer location.[3]

Briefly, the data recording system consists of duplicate electronic packages for the leading and trailing edge trays. Data from the system are a mix of high and low analog and parallel digital signals. The magnetic tape memory provides storage for approximately 14 megabits of data. Data are obtained by periodically scanning strain gage, thermister, solar power, quartz crystal microbalance, and the monitor of electronic piece part circuits.

2. DATA

The tray pairs must be put in flight electrical configuration to prepare the system to record data. Engineering batteries must be installed, and tray-

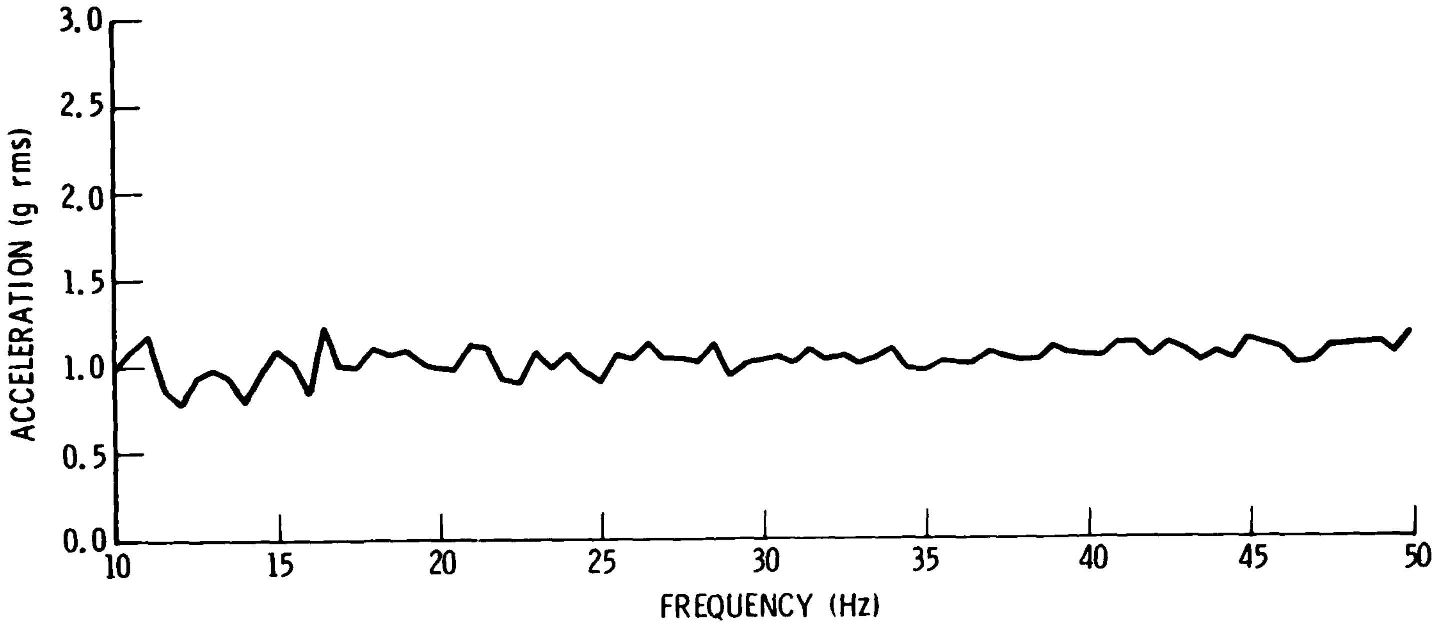


Fig. 25. T3, L-Axis, Transfer Function, Accelerometer No. 4/3

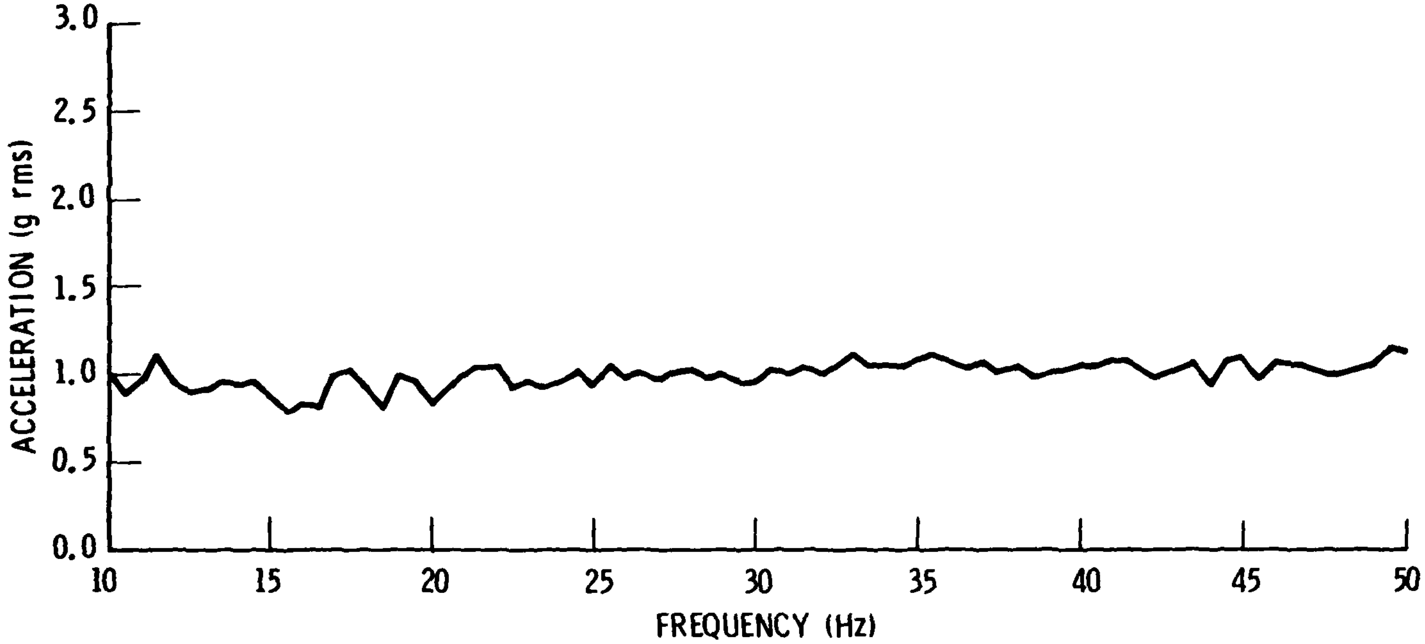


Fig. 26. T3, L-Axis, Transfer Function, Accelerometer No. 5/3

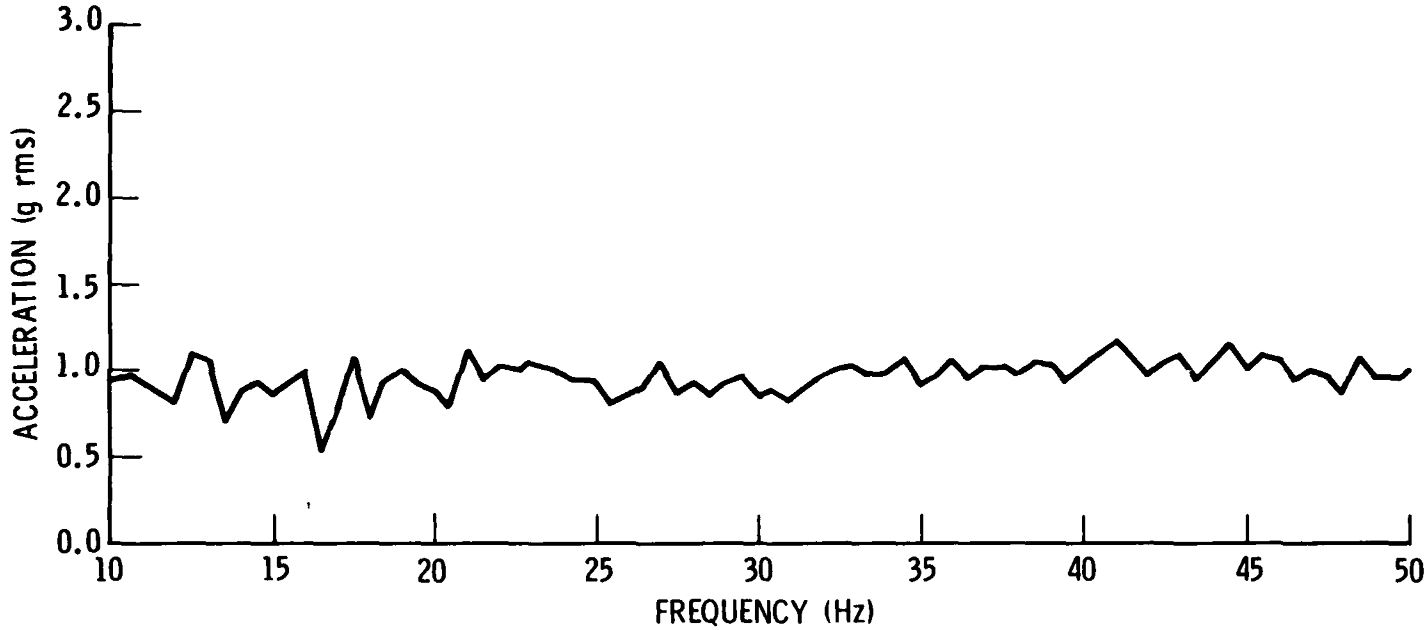


Fig. 27. T3, L-Axis, Transfer Function Accelerometer No. 6/3

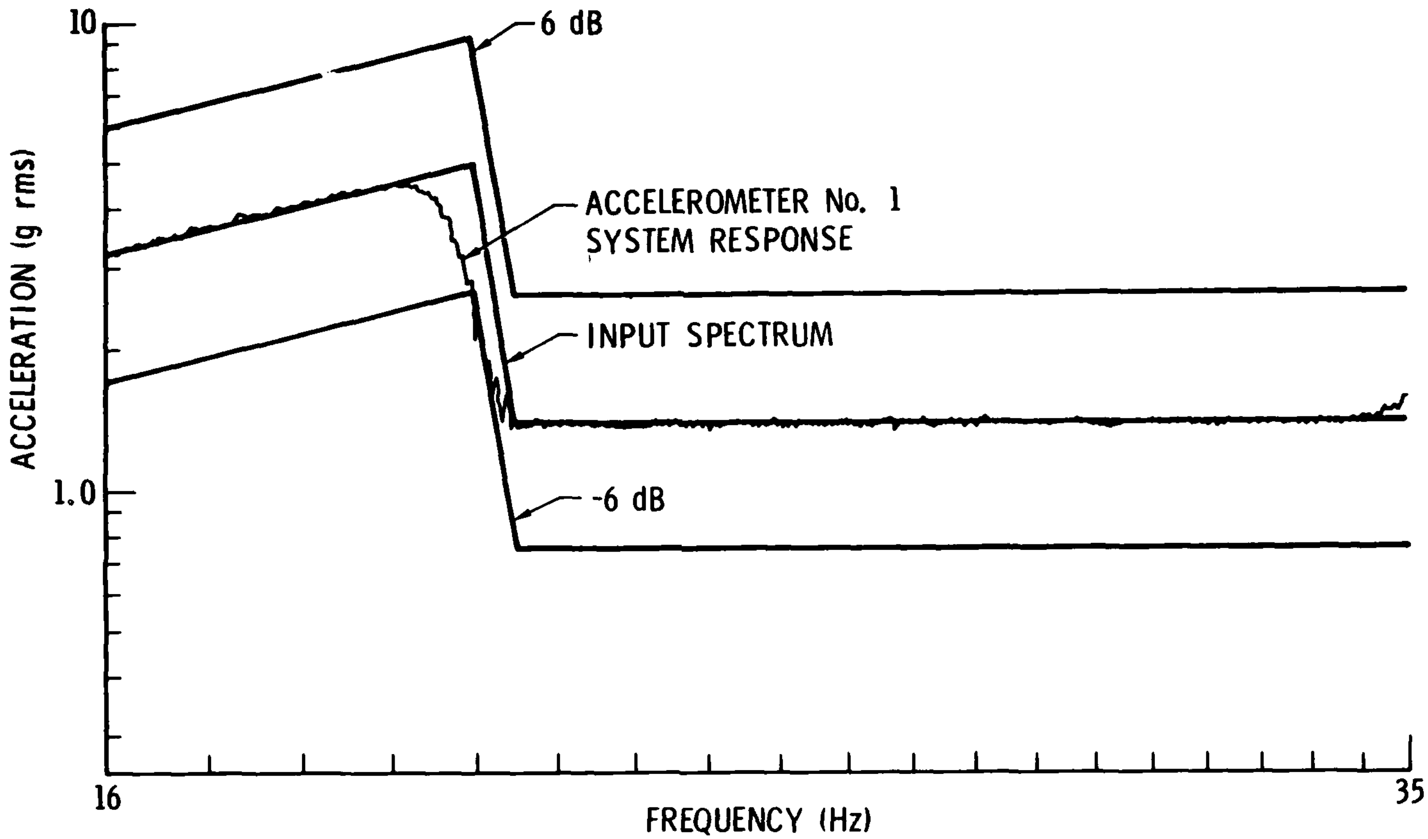


Fig. 28. T3, L-Axis, Sine Certification Input Spectrum, Accelerometer No. 1

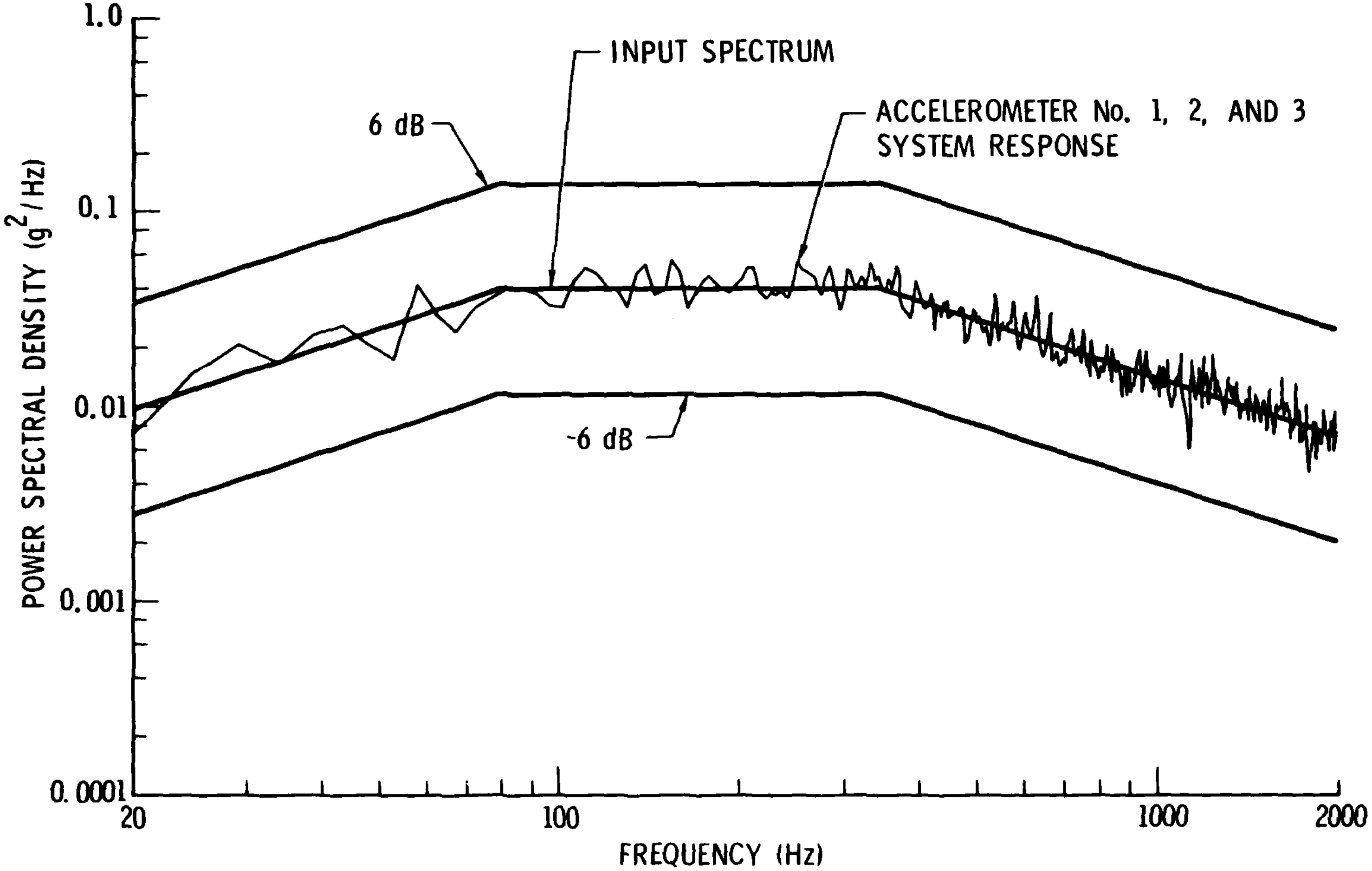


Fig. 29. T3, L-Axis, Random Certification Input Spectrum, Accelerometer No. 1, 2, and 3

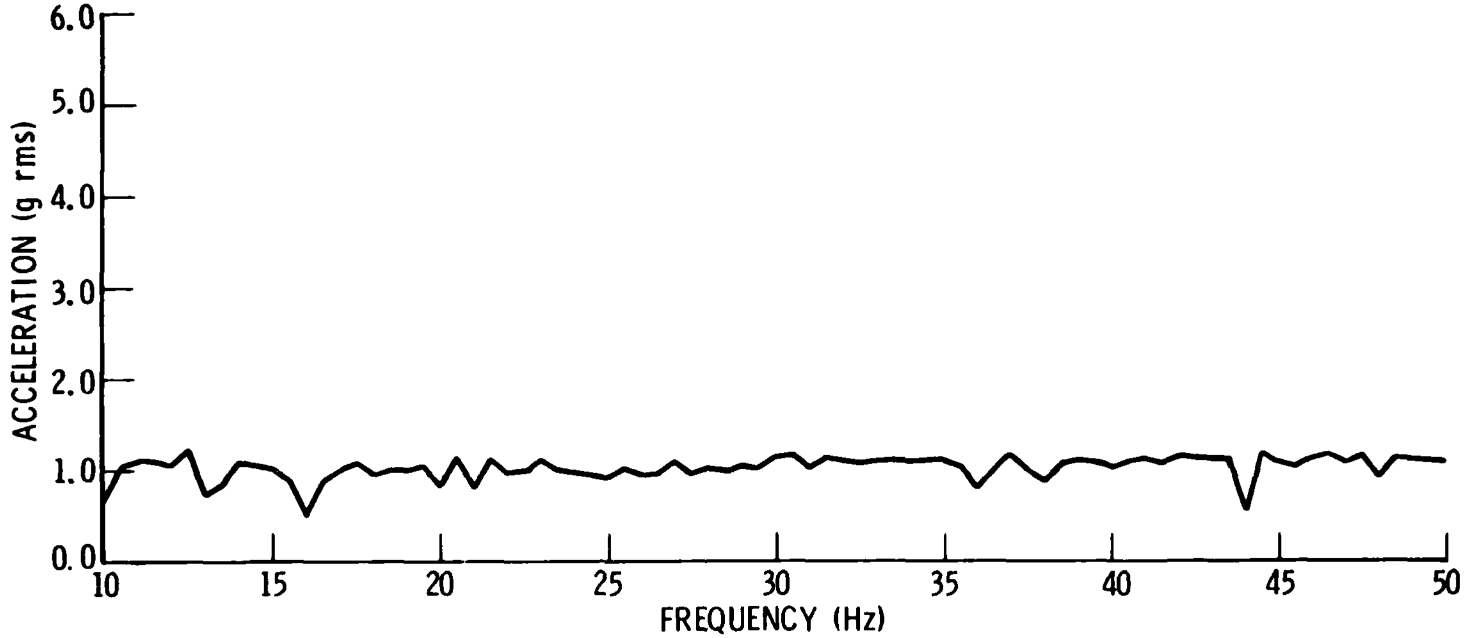


Fig. 30. T3, M-Axis, Transfer Function, Accelerometer No. 4/1

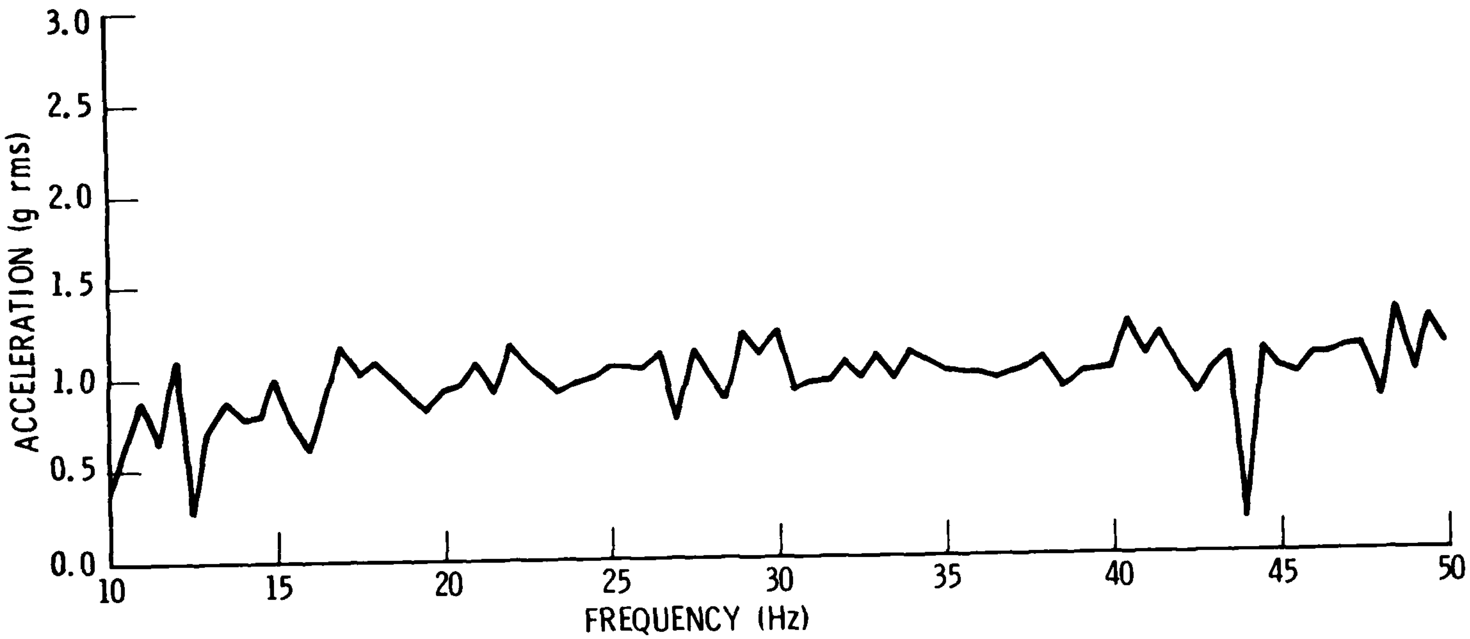


Fig. 31. T3, M-Axis, Transfer Function, Accelerometer No. 5/1

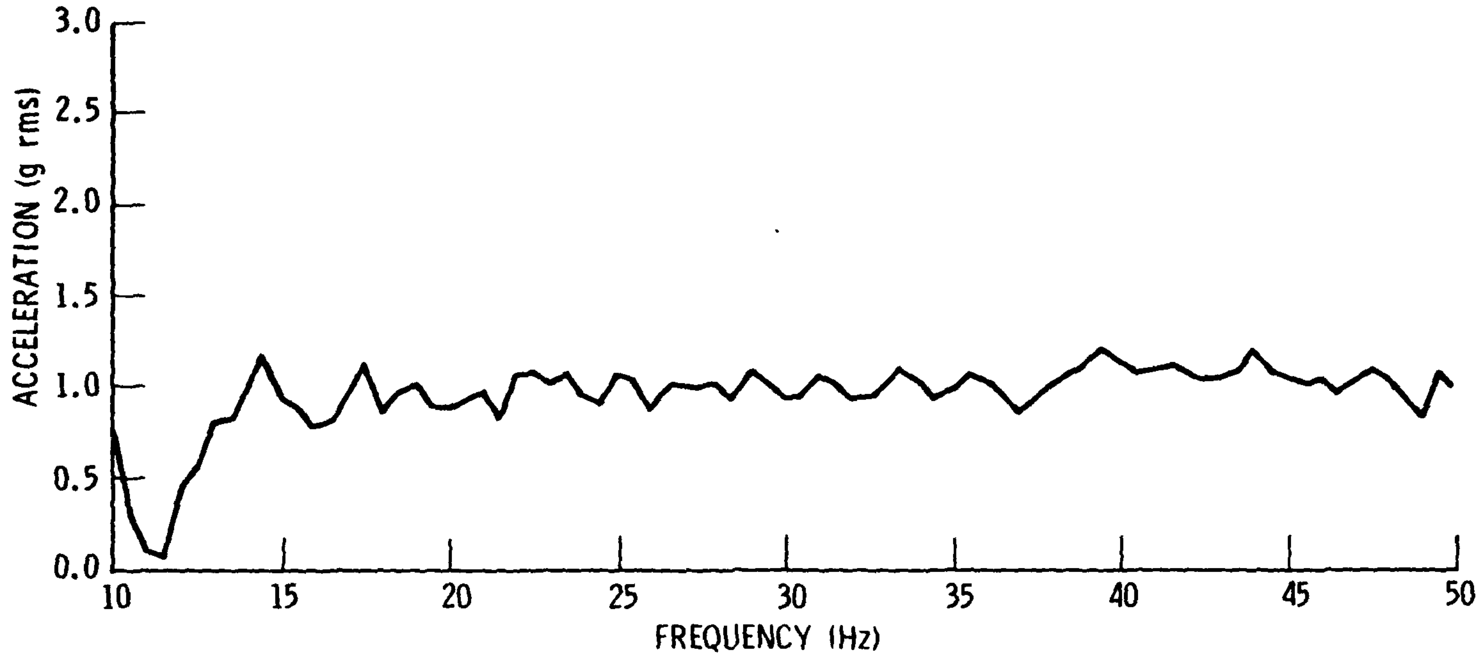


Fig. 32. T3, M-Axis, Transfer Function, Accelerometer No. 6/1

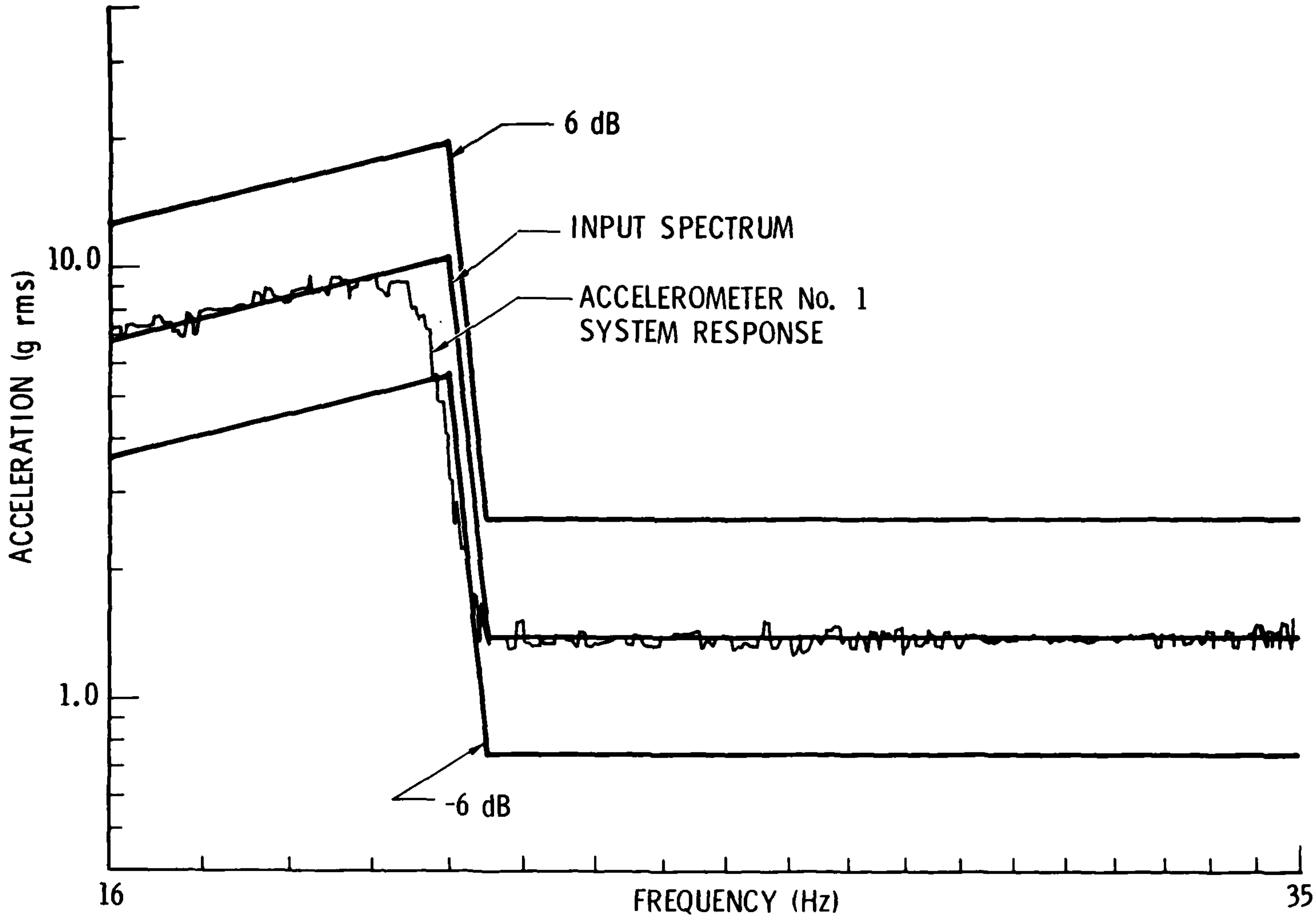


Fig. 33. T3, [illegible]-Axis, Sine Certification Input Spectrum, Accelerometer No. 1

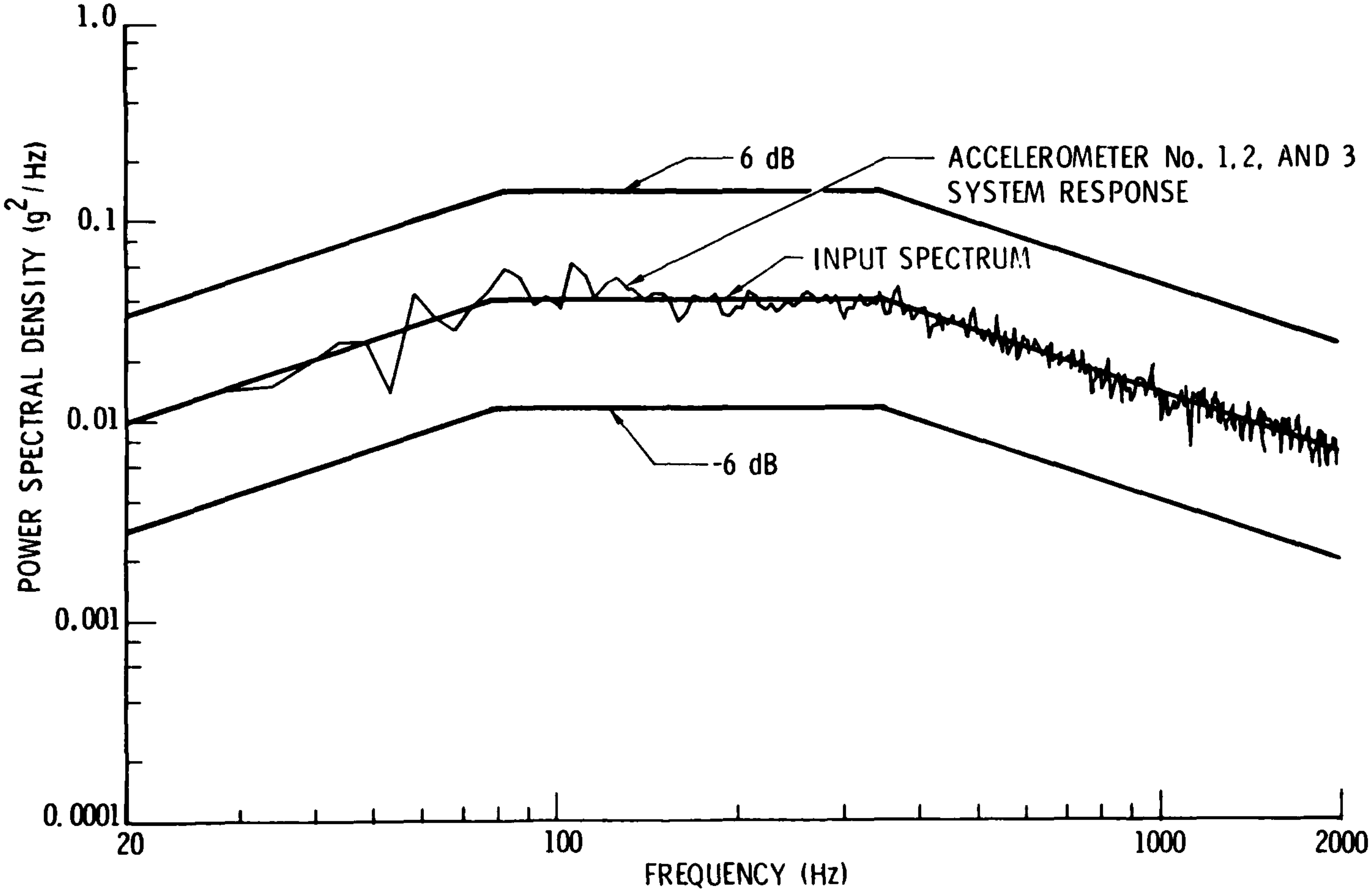


Fig. 34. T3, M-Axis, Random Certification Input Spectrum, Accelerometer No. 1, 2, and 3

tray jumper cables attached. Data collection is started by initiating the Engineering Power and Data System (EPDS). After a suitable data collection period has elapsed, the EPDS must again be initiated to terminate the data collection. Using ground support equipment, the data on the flight tape must be transcribed onto a computer compatible tape (CCT). The CCT is then read out by a microcomputer.

Both pre- and posttest data scans were conducted by first taking a quick look data scan to establish the state of each data channel. A 48-hr test run was then initiated to test the EPDS data timing function. A representative sample of the pre- and posttest data scans for the leading and trailing edge experiment trays are shown in Tables 4 and 5.

Table 4. Leading Edge Flight Trays, Pre- and Posttest Data Scans, Read-Averaged Values

Pretest				Posttest			
Number of Scans Averaged = 5				Number of Scans Averaged = 5			
Channel No.	Average Value	Channel No.	Average Value	Channel No.	Average Value	Channel No.	Average Value
7 BOE	0000000000	40 WRT-7	2.3808	7 BOE	0000000000	40 WRT-7	2.36128
8 QCM	1621	41 WRT-8	2.39056	8 QCM	1597	41 WRT-8	2.37104
9 SC-1	9.70383E-03	42 WRT-9	2.37104	9 SC-1	5.70946E-03	42 WRT-9	2.35152
10 SC-2	0.0296757	43 WRT-10	2.3808	10 SC-2	0.0256813	43 WRT-10	2.35152
11 SC-3	1.71509E-03	44 WRT-11	2.37104	11 SC-3	-6.27365E-03	44 WRT-11	2.35152
12 SC-4	-0.0142624	45 WRT-12	2.37104	12 SC-4	-0.010268	45 WRT-12	2.35152
13 SC-5	0.865625	46 WRT-13	2.36128	13 SC-5	0.0536421	46 WRT-13	2.34176
14 SC-6	0.0136982	47 WRT-14	2.3808	14 SC-6	5.70946E-03	47 WRT-14	2.35152
15 EPDS I	2.67397	48 WRT-15	2.37104	15 EPDS I	2.67397	48 WRT-15	2.35152
16 EPDS 12V	4.03024	49 EPDSVT	0.836768	16 EPDS 12V	4.03024	49 EPDSVT	0.0830912
17 EPDS 5V	3.87798	50 ANA-1	1.71517	17 EPDS 5V	3.8448	50 ANA-1	1.71712
18 CTS-1	2.36909	51 V TEMP	2.37104	18 CTS-1	2.35152	51 V TEMP	2.37104
19 CTS-2	2.37299	52 V TEMP	2.37104	19 CTS-2	2.35738	52 V TEMP	2.37104
20 CTS-3	2.3808	53 SG-1	-0.02992	20 CTS-3	2.36128	53 SG-1	-0.063104
21 CTS-4	2.3808	54 SG-2	0.081344	21 CTS-4	2.36128	54 SG-2	-4.54388E-03
22 LTT-1	4.61584	55 SG-3	-0.033824	22 LTT-1	4.61584	55 SG-3	-0.067008
23 LTT-2	4.6256	56 SG-4	-0.0299201	23 LTT-2	4.61584	56 SG-4	-8.44803E-03
24 LTT-3	4.61584	57 SG-5	-0.035776	24 LTT-3	4.61584	57 SG-5	-0.63104
25 LTT-4	4.61584	58 SG-6	-0.0318721	25 LTT-4	4.61194	58 SG-6	-0.0494399
26 LTT-5	4.61584	59 SG-7	-0.061152	26 LTT-5	4.61194	59 SG-7	-0.13728
27 LTT-6	4.61584	60 SG-8	-0.0338241	27 LTT-6	4.60608	60 SG-8	-0.0787201
28 HTT-1	1.15104	61 SG-9	-0.084576	28 HTT-1	1.14128	61 SG-9	-0.11776
29 HTT-2	1.1608	62 SG-10	1.31207E-03	29 HTT-2	1.14128	62 SG-10	-0.11776
30 HIT-3	1.1608	63 SG-11	-0.0104	30 HTT-3	1.15104	63 SG-11	-0.0338241
31 HTT-4	1.1608	64 SG-12	-0.055296	31 HTT-4	1.14128	64 SG-12	-0.0787201
32 HTT-5	1.15104	65 SG-13	-0.065056	32 HTT-5	1.14128	65 SG-13	-0.108
33 HTT-6	1.15104	66 SG-14	-0.0260161	33 HTT-6	1.13152	66 SG-14	-0.0591999
34 WRT-1	2.3808	67 SG-15	-0.0650561	34 WRT-1	2.37104	67 SG-15	-0.197792
35 WRT-2	2.3808	68 SG-16	-0.0494399	35 WRT-2	2.36128	68 SG-16	-0.11776
36 WRT-3	2.37104	69 SG-17	-0.070912	36 WRT-3	2.36128	69 SG-17	-0.08848
37 WRT-4	2.3808	70 SG-18	-0.0513919	37 WRT-4	2.36714	70 SG-18	-0.0728642
38 WRT-5	2.39056	71 SG-19	-0.0709121	38 WRT-5	2.36128	71 SG-19	-0.08848
39 WRT-6	2.3808	72 SG-20	-0.0572479	39 WRT-6	2.36128	72 SG-20	-0.0318721

Table 5. Trailing Edge Flight Trays, Pre- and Posttest Data Scans, Read-Averaged Value

Pretest				Posttest			
Number of Scans Averaged = 5				Number of Scans Averaged = 5			
Channel No.	Average Value	Channel No.	Average Value	Channel No.	Average Value	Channel No.	Average Value
7 BOE	0000000000	40 WRT-7	2.40192	7 BOE	0000000000	40 WRT-7	2.33374
8 QCM	1305	41 WRT-8	2.41166	8 QCM	1313	41 WRT-8	2.33374
9 SC-1	0.0142677	42 WRT-9	2.40192	9 SC-1	0.0142677	42 WRT-9	2.33374
10 SC-2	0.0222069	43 WRT-10	2.39218	10 SC-2	0.0142677	43 WRT-10	2.33374
11 SC-3	0.0182373	44 WRT-11	2.39218	11 SC-3	0.0102982	44 WRT-11	2.33374
12 SC-4	6.32858E-03	45 WRT-12	2.41166	12 SC-4	6.32858E-03	45 WRT-12	2.34322
13 SC-5	0.0261765	46 WRT-13	2.40192	13 SC-5	0.0142677	46 WRT-13	2.35322
14 SC-6	6.32858E-03	47 WRT-14	2.41166	14 SC-6	0.0102982	47 WRT-14	2.36296
15 EPDS I	2.72947	48 WRT-15	2.41166	15 EPDS I	2.7136	48 WRT-15	2.36296
16 EPDS 12V	4.05772	49 EPDSVT	0.9604	16 EPDS 12V	4.05772	49 EPDSVT	0.808456
17 EPDS 5V	3.8785	50 WRT-16	2.41166	17 EPDS 5V	3.84149	50 WRT-16	2.3727
18 CTS-1	2.40192	51 V TEMP	2.4214	18 CTS-1	2.324	51 V TEMP	2.34348
19 CTS-2	2.40192	52 V TEMP	2.4214	19 CTS-2	2.324	52 V TEMP	2.34348
20 CTS-3	2.41166	53 SG-1	-0.107104	20 CTS-3	2.31426	53 SG-1	-0.116844
21 CTS-4	2.41166	54 SG-2	-0.525603	21 CTS-4	2.324	54 SG-2	-0.0623002
22 LTT-1	4.63238	55 SG-3	-0.0291842	22 LTT-1	4.6129	55 SG-3	0.0350281
23 LTT-2	4.63238	56 SG-4	-0.0213923	23 LTT-2	4.6129	56 SG-4	-0.233402
24 LTT-3	4.62264	57 SG-5	-0.0895723	24 LTT-3	4.60316	57 SG-5	-0.16944
25 LTT-4	4.62459	58 SG-6	-0.0934683	25 LTT-4	4.6129	58 SG-6	-0.10126
26 LTT-5	4.63238	59 SG-7	-0.08178	26 LTT-5	4.60316	59 SG-7	-0.0895722
27 LTT-6	4.63238	60 SG-8	-0.0525603	27 LTT-6	4.6129	60 SG-8	-0.0545082
28 HTT-1	1.16494	61 SG-9	-0.08178	28 HTT-1	1.11624	61 SG-9	-0.0973642
29 HTT-2	1.17468	62 SG-10	-0.0545083	29 HTT-2	1.13182	62 SG-10	-0.0837281
30 HTT-3	1.16494	63 SG-11	-0.0486642	30 HTT-3	1.11624	63 SG-11	-0.0467161
31 HTT-4	1.16494	64 SG-12	-0.038924	31 HTT-4	1.11624	64 SG-12	-0.0584043
32 HTT-5	1.16494	65 SG-13	-0.0642482	32 HTT-5	1.11624	65 SG-13	-0.0661962
33 HTT-6	1.17468	66 SG-14	-0.0720401	33 HTT-6	1.14546	66 SG-14	-0.0876242
34 WRT-1	2.39218	67 SG-15	-0.10126	34 WRT-1	2.324	67 SG-15	-0.157752
35 WRT-2	2.39218	68 SG-16	-0.12074	35 WRT-2	2.324	68 SG-16	-0.185024
36 WRT-3	2.39218	69 SG-17	-0.0506123	36 WRT-3	2.33374	69 SG-17	-0.0408721
37 WRT-4	2.39218	70 SG-18	-0.08178	37 WRT-4	2.33374	70 SG-18	-0.0934683
38 WRT-5	2.39218	71 SG-19	-0.0798321	38 WRT-5	2.324	71 SG-19	-0.0934683
39 WRT-6	2.41166	72 SG-20	-0.044768	39 WRT-6	2.34543	72 SG-20	-0.0564563

IV. EXPERIMENT WEIGHT AND CENTER OF GRAVITY

Prior to the certification vibration tests, the weight and center of gravity of each experiment tray were determined.

The equipment used for this experiment consisted of a tray holding fixture, three load cells and associated readout instrumentation, and an HP85 computer. Experiment weight and geometric center versus measured center of gravity data are presented in Table 6. The location of the center of gravity for each tray is shown in Figs. 35 through 38.

Table 6. Tray Weight and Center of Gravity

Tray	Weight (lb)	Geometric Center x^a	Geometric Center y	Measured Center of Gravity x	Measured Center of Gravity y	Error Radius (in.)	Unbalance (ft-lb)
T3	122.31	23.375	29.437	25.723	29.301	2.35	23.57
L3	107.25	23.375	29.437	25.061	27.153	2.83	25.37
T6	241.19	23.375	29.437	20.654	27.485	3.34	67.29
L6	240.01	23.375	29.437	20.743	27.366	3.34	66.97

[a]All x,y values are distances from a fixed reference point outside the tray boundaries.

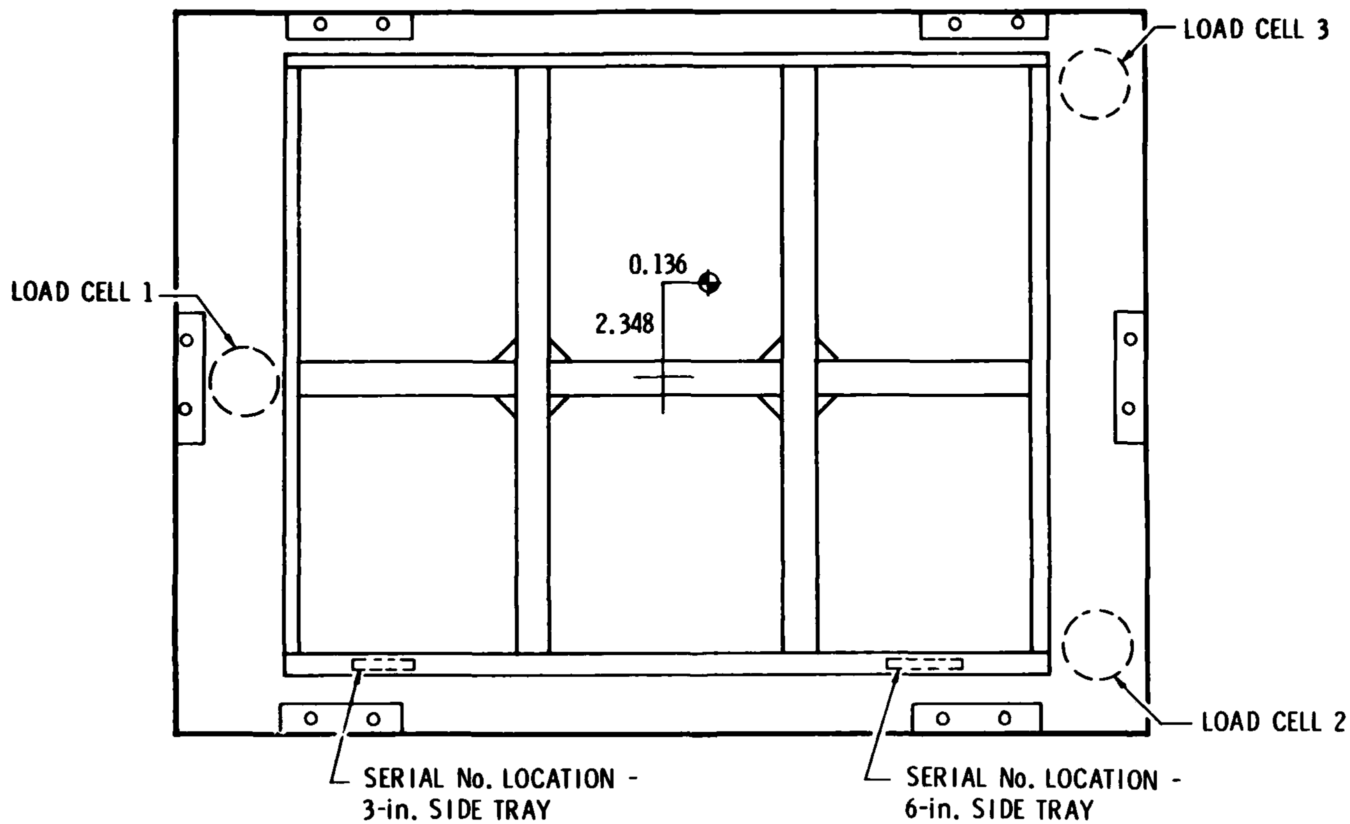


Fig. 35. T3, Measured Center of Gravity

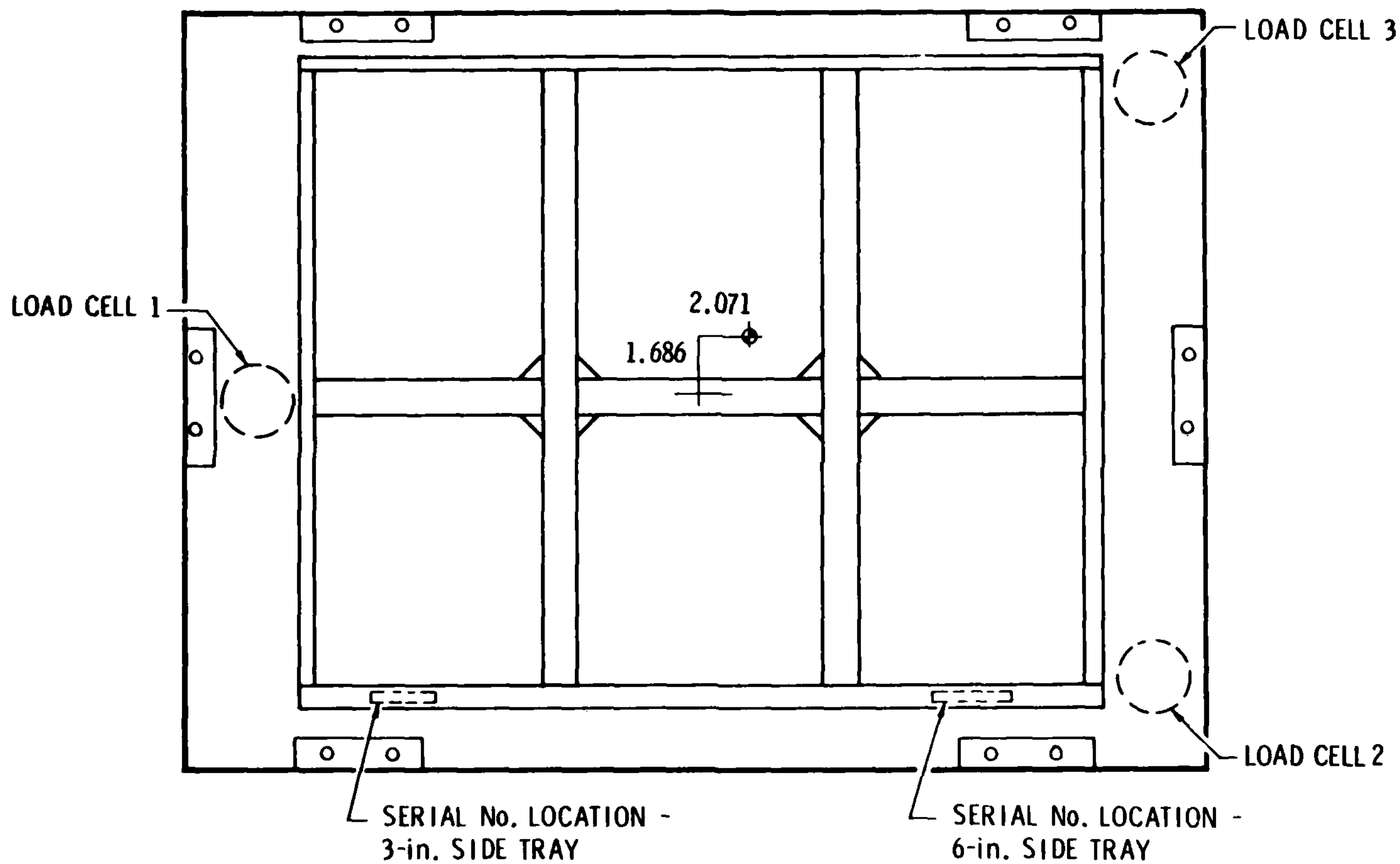


Fig. 36. L3, Measured Center of Gravity

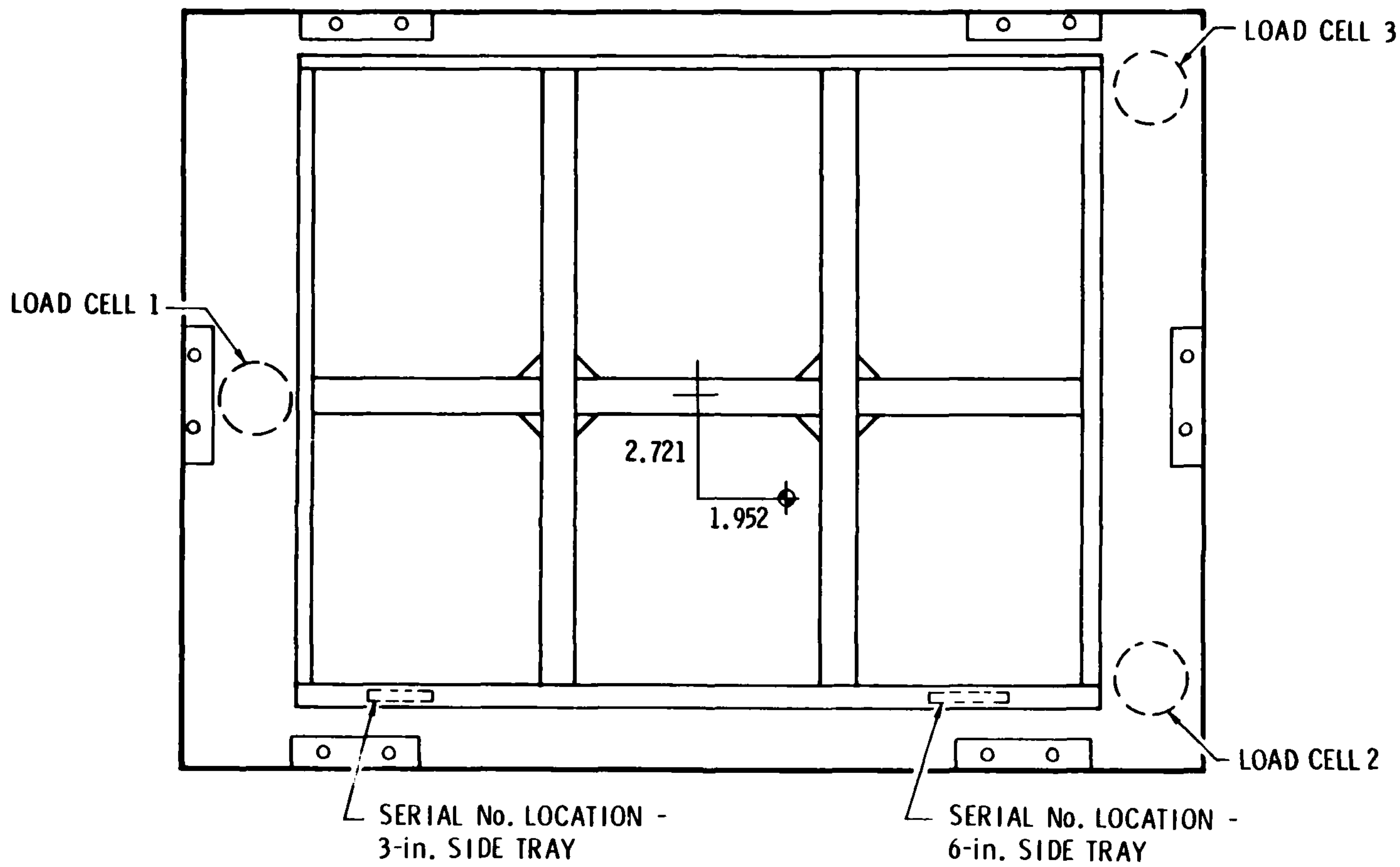


Fig. 37. T6, Measured Center of Gravity

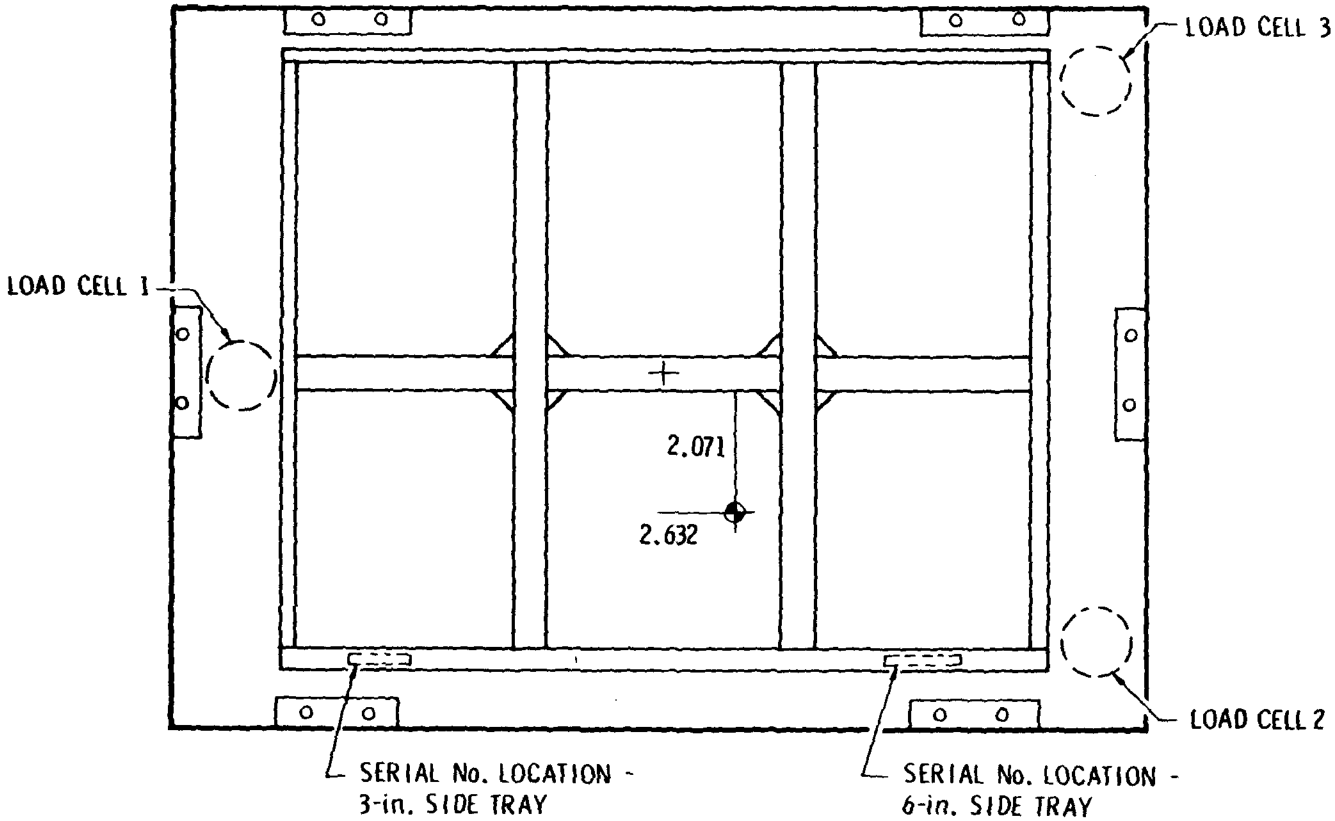


Fig. 38. L6, Measured Center of Gravity

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1. A. F. DiGiacomo, Qualification Vibration Test Report for SD802 Materials Experiment, TR-0081(6950-05)-3, The Aerospace Corporation, El Segundo, Calif. (3 August 1981).

2. A. F. DiGiacomo, W. C. Burns, and P. Schall, Environmental Qualification Tests, Signal Conditioning Unit, SD802 Materials Experiment, TR-0083(3935-05)-1, The Aerospace Corporation, El Segundo, Calif. (to be published).

3. R. P. Giguere, SD/LDEF Technical User's Manual, TR-0081(6603)-1, The Aerospace Corporation, El Segundo, Calif. (30 September 1981).

APPENDIX A

M0003 DATA RECORDING

FUNCTIONAL TESTS

Revised 23 November 1982

M0003 DATA RECORDING FUNCTIONAL TESTS

1.0 Battery Installation

1.1 Function Tests

1.1.1 Experiment Power, Two (12V) Batteries, 3 Inch Trays

1.1.2 EPDS, 7.5 and 12V Battery, 6 Inch Trays

1.1.3 EECC, Not to be opened before flight

1.2 Flight Readiness

1.2.1 Experiment Power, Two (12V) Batteries, 3 Inch Trays

1.2.2 EPDS, 7.5 and 12V Battery, 6 Inch Trays

1.2.3 EECC, 7.5 and 28V Battery, 6 Inch Trays

2.0 Wire Connections

2.1 Connect 3" Tray to 6" Tray Interface Cables

2.1.1 Leading Edge Trays

	Cable Connection		Tray Connection
6" Tray (LE155 629C-10)			
	S110	to	P110
	S111	to	P111
	S112	to	P112
3" Tray (LE155 621A-1-3			
	P107	to	S107
	P108	to	S108
	P109	to	S109

2.1.2 Trailing Edge Trays

3" Tray (LE155621A-1-11	P207	to	S207
	P208	to	S208
6" Tray (LE155 629C-7)	S209	to	P209
	P210	to	S210

2.2 Remove flight jumper connection located on bottom surface of EPDS

2.3 Ground Support Equipment Connections

2.3.1 P1 DPCA to a) S703 (EPDS)

b) P - MTM Controller

c) J5 Power MTM Controller

2.3.2 P2 CCT INT/FACE to P1 Kennedy CCT

3.2 GSE Power Turn On

- Turn on the 115 VAC Power Switch
- The Initiate Monitor RESET Lamp Should Be On
- The 10 VDC Meter Should Read 7.5V
- The 15 VDC Meter Should Read 12V
- Move Spring Loaded Printer Switch to the RESET Position
- 12 VDC EPDS Power Switch to the ON Position
- 7.5 VDC EPDS Power Switch to the ON Position
- 12 VDC Experiment Power Switch to the ON Position
- 7.5 VDC Experiment Power Switch to the ON Position
- External 12 VDC, Negative Power Supply, to the ON Position
- Zero Current Reading on the Current Meter

3.3 EPDS Tape to Starting Position for Data Recording

3.3.1 Set Tape to Track #1

- DPCA-Manual Switch to the MANUAL Position
- Press Fast-Reverse (F-REV) button
  - a) Allow tape to remain in this mode until the stop lamp indicates stop
  - b) When the stop lamp is on the Track #2 indicating lamp will light
- press the forward switch (FWD) then press the record switch (REC)
  - a) Track #2 lamp will shut off, Track #1 lamp will turn on
  - b) Remain in the mode for <u>three minutes</u> and press the stop button
  - c) Track #1 lamp will turn off, Track #2 lamp will turn on

- ERASE ENABLE Switch to the ERASE ENABLE Position
  ERASE ENABLE Lamp will light
- Press the fast reverse (F REV) button and allow the tape to run until the tape STOP lamp turns on
- Turn the ERASE ENABLE Switch to the deactivated position
- Press the forward (FWD) button then press the record (REC) button, let the tape run for <u>one minute</u> and press the STOP button
- STOP lamp and Track #2 lamp should be on

4.0 Functional Tests

4.1 Primary checkout procedure

Data recording fot the purpose of playing the data back through the CCT and TRS-80 Computer and printer

Experiment powered through the DDB

4.1.1 For the combined post shipment and pre and post EPDS modification electronic functional test, record data for a minimum of thirty minutes

4.1.2 For subsequent electronic functional tests, record data for a minimum of 112 minutes

4.1.3 Switch arrangements for data recording

a) DPCA-MANUAL Switch to the DPCA Position

b) DDP Printer RESET Switch to the RESET Position

c) INITIATE SET-RESET Switch to the SET Position. This switch arrangement will provide a GSE print tape while the EPDS is recording data

d) 7.5 V current meter switch to the 1.5 ma position, meter should read ≈ 0.6 ma. (will overshoot initially)

e) After approximately 3.5 minutes the system will start recording data. The GSE printer will also start printing. NOTE: The GSE print tape will only print 5 channels of data during one print sequence, to print a full data scan on the GSE rpinter the system must remain activated for two hours. The printer will stop after it has printed the 72 data channels.

4.2 To transfer data from the EPDS tape to the CCT then to the TRS-80 computer

- Reset the INITIATE switch from the SET position to RESET position. Stops the data collection sequence
- DPCA-MANUAL switch to the manual position
- MTM Controller, press the fast reverse (F REV) button, allow the tape to run until the stop lamp turns on. At this point the Track #2 lamp will also turn on
- Press MTM controller forward (FWD) and (REC) button and let the tape run for 30-45 sec.
- Press the Stop button, the EPDS tape is now advanced

The next step is to transfer the data from EPDS to the Kennedy CCT

- Read-Write switch to the WRITE position
- Kennedy CCT, turn on the 115 VAC power switch and press the LOAD button. Install magnetic tape if required - See Kennedy Manual
- Press the ON LINE button, when the CCT is ready to accept data the ON LINE, WRITE ENABLE, WRITE STATUS and LOAD lamps will light
- MTM Controller, press the forward (FWD) button and then the reproduce (REPRO) button. This will start the transfer of data from the EPDS tape to the Kennedy CCT
- The Kennedy CCT will move in short increments, 10-15 seconds between increments, until all the data is transferred - the incremental movement of the Kennedy CCT will stop
- Push the STOP button on the MTM controller to stop the EPDS tape
- Push the ON LINE button, ON LINE lamp will go off

4.2.1 To Transfer Data from the Kennedy CCT to the TRS-80 Computer then onto the printer

- READ-WRITE switch to the READ position
- Press REWIND on the Kennedy CCT, the CCT will rewind and stop

- Turn on the 115 VAC power to the TRS-80 computer, printer and cassette recorder
- Load LDEF Program tape and read the program from the cassette into the TRS-80 computer
  - a) Load cassette into the cassette player
  - b) Press the LOAD switch on the cassette player
  - c) Type CLOAD on the keyboard and press the ENTER key on the keyboard
  - d) The cassette tape will start running, when it stops the program is loaded into the TRS-80 computer, rewind the cassette tape.
  - e) To insure that all the data was transferred from the program tape to the computer repeat steps a) thru d). In Line c) replace CLOAD with CLOAD?
- Press the ON LINE button on the Kennedy CCT, the ON LINE lamp will light, the WRITE ENABLE lamp will turn on
- Type the word RUN on the keyboard and press the enter key
  - a) The computer will ask which set of data are we working with leading or trailing edge trays, type in the appropriate letter L or T and press the ENTER key
  - b) If a time printout only is wanted ansser "YES" to the next question the computer displays. If the answer is "NO" just press the ENTER key
  - c) The computer now will transcribe and printout the data on the CCT, data Channels 7 through 72

4.3 Alternate test #1, this procedure may be used in case of electronic problems with the Kennedy tape or TRS-80 Computer. GSE Paper Tape Printout Only, Experiment Power Supplied by the Data Display Box (DDB)

4.3.1 Initiate, SET-RESET Switch Move to the SET position will now provide a GSE Papser Tape Printout

4.3.2 INITIATE Switch to the SET Position

a) The initiate monitor set lamp will light

b) -7.5 current meter, on the 1.5 ma scale, will read full scale then drop to .6 ma

c) 12V current meter will be < 100 ma

4.3.3 After approximately 3.5 minutes the GSE printer will start displaying data in bursts of 5 data channels. This sequence will continue until the 72 data channels are displayed (≈ 2 Hrs)

4.3.4 To Stop the system in this mode, SET and RESET Swtich to the RESET position. If GSE Paper Tape is to be restarted, PRINTER RESET Switch to RESET position

4.4 Alternate test #2, this procedure may be used in case of

a) partial malfunction of GSE equipment

b) data recording with the experiment in the Flight Configuration (Flight battery power)

c) Data recording for the purpose of checking the data collection timing sequence from initiate to beyond 94 hours continuous recording

4.4.1 Switch Arrangements

a) INT-EXT EPDS Power switch to INT position

b) DPCA-MANUAL switch to the MANUAL position

c) Initiate SET and RESET switch to the SET position. NOTE: No GSE tape printout

d) To stop the collection of data, initiate SET-RESET Switch to the RESET position. RESET lamp will turn on

4.4.2 To obtain a TRS-80 Computer printout repeat Steps 4.2 & 4.2.1

APPENDIX B

LDEF PROJECT

LDEF PROJECT

Procedure No.: ______________________

Procedure Title: Experiment Certification Vibration Test Procedure

Item Nomenclature: ______________________

Item Identification No.: ______________________

Prepared By: John F. Rogers 1-10-83
John F. Rogers- LDEF Experiment Test Engineer

Concurrence: Carol C. Kiser 1-10-83
Carol C. Kiser - LDEF Experiment Integration Manager

Approved By: W H Kinard
W. H. Kinard - Chief Scientist and Experiment Manager

Leo P. Daspit Jr. 1-10-83
L. P. Daspit, Jr. - LDEF Project Manager

George King for Tom Moore
C. T. Moore - Quality Assurance

Test Engineer: ______________________

Date Started: ______________________

Date Completed: ______________________

1.0 GENERAL

1.1 Test Objective

1.1.1 To verify the structural integrity of the experiment when subjected to the certification vibration test levels.

1.1.2 To demonstrate the ability of the experiment to satisfy functional requirements after being subjected to the certification vibration test levels.

1.2 Test Description

1.2.1 The experiment vibration fixture (LE155606C) will be mounted on the Unholtz-Dickie shaker in Building 1250. The experiment will then be tested to the sine and random vibration spectrums as identified in Figure 3 and 4.

1.3 Personnel Requirements

1.3.1 Test Engineer (T.E.)

1.3.1.1 The test engineer shall have the overall responsibility for direction of this test.

1.3.2 Test Facility Operator (T.F.O.)

1.3.3 Quality Assurance Technician (R&QA)

1.3.4 Experiment Development Organization Representative (E.D.O.)

1.3.4.1 Personnel from the Experiment Development Organization will be present when appropriate.

1.4 Safety

1.4.1 Safety requirements are specified in the individual steps of section 2.3 (Vibration Testing).

1.5 Quality Assurance

1.5.1 A quality assurance representative will observe and assure adherence to this test procedure.

1.6 Test Facility and Equipment

1.6.1 Facility

1.6.1.1 Environment test lab located Building 1250.

1.6.2 Equipment

1.6.2.1 Shaker and associated vibration controller/analyzer available in the specified test facility.

1.6.2.2 Integrated Experiment Tray/Module

1.7 Failure Criteria

1.7.1 Loose parts, cracks in the structure, or evidence of component failure based on accelerometer response data will constitiute a failure.

1.8 Log Book

1.8.1 A log book will be maintained for each experiment.

2.0 <u>TESTING</u>

2.1 Test Sequence

2.1.1 The vibration tests shall be conducted in the following sequence for each axis (N, L, M).

2.1.1.1 Transfer functions

2.1.1.2 Certification level sine sweep

2.1.1.3 Certification level random vibration

2.2 Instrumentation

2.2.1 Sine Test

2.2.1.1 The locations of the control and response accelerometers for each axis are identified in figure 5, 6, 7.

2.2.1.2 Control and response accelerometer data will be plotted in G's vs. frequency at the completion of the test.

2.2.2 Random Test

2.2.2.1 The location of the control accelerometer for each axis is identified in figure 5, 6, and 7.

2.2.2.2 Control accelerometer data will be plotted in GRM's vs frequency at the completion of the test.

2.3 Vibration Testing

2.3.1 Transfer Functions (N Axis)

2.3.1.1 Install the experiment vibration fixture (LE155606C) on the vertical shaker for "N" axis testing. Torque the 1/2" bolts to 90 ft-lbs.

2.3.1.2 Attach the integrated experiment tray/module to the vibration fixture using clamp blocks and shims as per LE155639 for side trays or LE155652 for end trays. Torque the 1/4-28 bolts to 75 in-lbs.

2.3.1.3 Assure that all instrumentation has been properly calibrated.

2.3.1.4 Attach the control ________ and response ________ accelerometers as shown in figure 5.

2.3.1.5 Determine the transfer function between these points and additional points as deemed necessary by the test engineer.

2.3.1.6 Review the transfer function data noting fundamental frequencies. If a fundamental frequency < 35Hz is noted then special consideration should be given to this experiment package.

________ QA

2.3.2 Certification Level Sine Sweep (N Axis)

2.3.2.1 Verify that the proper sine test has been recorded on the disk (the "G" level is specified in Figure 2, the spectrum is as shown in Figure 3, the test will be conducted from 35-16 Hz).

________ QA

2.3.2.2 Subject the experiment package to the cerification level sine sweep.

2.3.2.3 Review the response acceleration data and perform a visual inspection of the experiment package to insure compliance with the failure criteria.

____
QA

2.3.3 Certification Level Random Vibration (N Axis)

2.3.3.1 Verify that the random certification test level has been recorded on the disk (see Figure 4).

____
QA

2.3.3.2 Verify that the control accelerometer is________as shown in Figure 5.

2.3.3.3 Subject the experiment package to the random certification test.

2.3.3.4 Perform a visual inspection of the experiment package to insure compliance with the failure criteria.

____
QA

2.3.4 Transfer Functions (L Axis)

2.3.4.1 Remove the accelerometers from the experiment tray and vibration fixture.

2.3.4.2 Remove the integrated experiment tray/module from the vibration fixture and attach it to the handling fixture.

2.3.4.3 Remove the vibration fixture from the shaker head and install it on the slippery table oriented for "L" axis testing (see Figure 6). Torque the 1/2" bolts to 90 ft-lbs.

2.3.4.4 Rotate the shaker head 90° and attach it to the slippery table. Torque the 1/2" bolts to 90 ft-lbs.

2.3.4.5 Atttach the integrated experiment tray/module to the vibration fixture using clamp blocks and shims as per LE155639 for side trays or LE155652 for end trays. Torque the ¼-28 bolts to 75 in-lbs.

2.3.4.6 Attach the control________ and response________ accelerometers as shown in Figure 6.

2.3.4.7 Determine the *transfer function* between these points and additional points as deemed necessary by the test engineer.

2.3.4.8 Review the transfer function data noting fundamental frequencies. If a fundamental frequency 35 Hz is noted then special consideration should be given to this experiment package.

____
QA

2.3.5 Certification Level Sine Sweep (L Axis)

2.3.5.1 Verify that the proper sine test has been recorded on the disk (the "G" level is specified in Figure 2, the spectrum is as shown in Figure 3, the test will be conducted from 35-16 Hz).

________ QA

2.3.5.2 Subject the experiment package to the certification level sine sweep sine sweep.

2.3.5.3 Review the response acceleration data and perform a visual inspection of the experiment package to insure compliance with the failure criteria.

________ QA

2.3.6 Certification level random vibration (L axis)

2.3.6.1 Verify that the random certification test level has been recorded on the disk (see Figure 4).

2.3.6.2 The control accelerometer is_______as shown in Figure 6.

________ QA

2.3.6.3 Subject the experiment package to the random certification test.

2.3.6.4 Perform a visual inspection of the experiment package to insure compliance with the failure criteria.

________ QA

2.3.7 Transfer function (M Axis)

2.3.7.1 Remove the accelerometers from the experiment tray and vibration fixture.

2.3.7.2 Remove the integrated experiment tray/module from the vibration fixture and attach it to the handling fixture.

2.3.7.3 Rotate the vibration fixture on the slippery table so that it is oriented for "M" axis testing. Torque the 1/2" bolts to 90 ft-lbs.

2.3.7.4 Attach the integrated experiment tray/module to the vibration fixture using clamp blocks and shims as per LE155639 for side trays or LE155652 for end trays. Torque the 1/4-28 bolts to 75 in-lbs.

2.3.7.5 Attach the control________and response _______ accelerometers as shown in Figure 7.

2.3.7.6 Determine the transfer function between these points and additional points as deemed necessary by the test engineer.

2.3.7.7 Review the transfer function data noting fundamental frequencies. If a fundamental frequency 35 Hz is noted then special consideration should be given to this experiment package.

_______ QA

2.3.8 Certification Level Sine Sweep (M Axis)

2.3.8.1 Verify that the proper sine test has been recorded on the disk. (The "G" level is specified in Figure 2, the spectrum is as shown in Figure 3, the test will be conducted from 35-16 Hz).

_______ QA

2.3.8.2 Subject the experiment package to the certification level sine sweep.

2.3.8.3 Review the response acceleration data and perform a visual inspection of the experiment package to insure compliance with the failure criteria.

_______ QA

2.3.9 Certification level random vibration (M Axis)

2.3.9.1 Verify that the random certification test level has been properly recorded on the disk (see Figure 4).

2.3.9.2 The control accelerometer is_______as shown in Figure 7.

_______ QA

2.3.9.3 Subject the experiment package to the random certification test.

2.3.9.4 Perform a visual inspection of the experiment package to insure compliance with the failure criteria.

____
QA

2.3.9.5 Remove the accelerometers from the experiment package and vibration fixture.

2.3.9.6 Remove the integrated experiment tray/module from the vibration fixture and attach it to the handling fixture.

2.3.9.7 Generate all plots as required by this procedure.

2.3.10 This concludes certification vibration testing of this experiment.

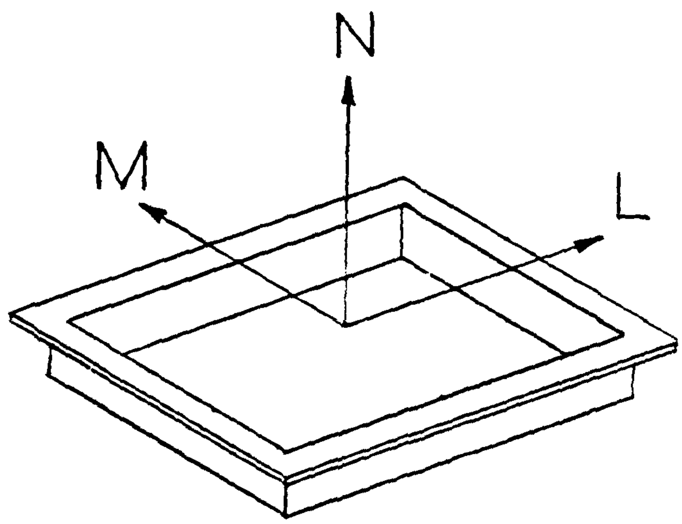


Figure 1. Experiment Coordinate System

EXPERIMENT NO.	LOCATION	SINE TEST LEVELS L	M	N
A0175	A1, A7	6.3	5.9	9.7
A0133	H7	11.9	11.9	6.4
A0019, A0180, A0023	D12	6.4	5.0	8.4
A0076	F9	5.0	12.0	5.0
M0003	D4, D8	5.0	9.2	5.6
M0002, M0003	D3, D9	5.0	10.6	5.0
S1001	F12	6.4	5.0	11.6
S1001	H1	11.9	11.9	6.4
A0023, S1006, S1003, M0002	E6	5.0	5.0	9.8
A0135, S0050, A0044	E5	5.0	5.2	9.0
M0002, A0147, A0056, A0172	G12	8.1	8.1	6.3
A0139A	G6	8.1	8.1	6.3
P0003	CR			
A0189, A0172, S0001	D2	5.6	9.7	5.6
M0004	F8	5.0	10.5	6.0
A0056, A0147, S0001	B8	5.0	12.3	8.7
A0023, A0114, A0034, A0201	C3	5.0	14.3	5.0
A0023, A0114, A0034, A0201	C9	5.0	13.4	5.0
S0109	C12	6.3	5.0	8.3
A0201, S0001	D6	5.0	5.0	8.1
S0079	F2	5.6	10.2	6.4
A0023, A0201	H11	11.9	11.9	6.4
A0015, A0187, M0006	C2	5.6	11.5	7.4
A0201	B12	6.3	5.0	8.8
S0001	A12, F1, B11	11.9	12.9	10.2
S0001	G8	8.1	8.1	6.3

Figure 2. Certification Level Sine Sweep (L, M, and N Axes)

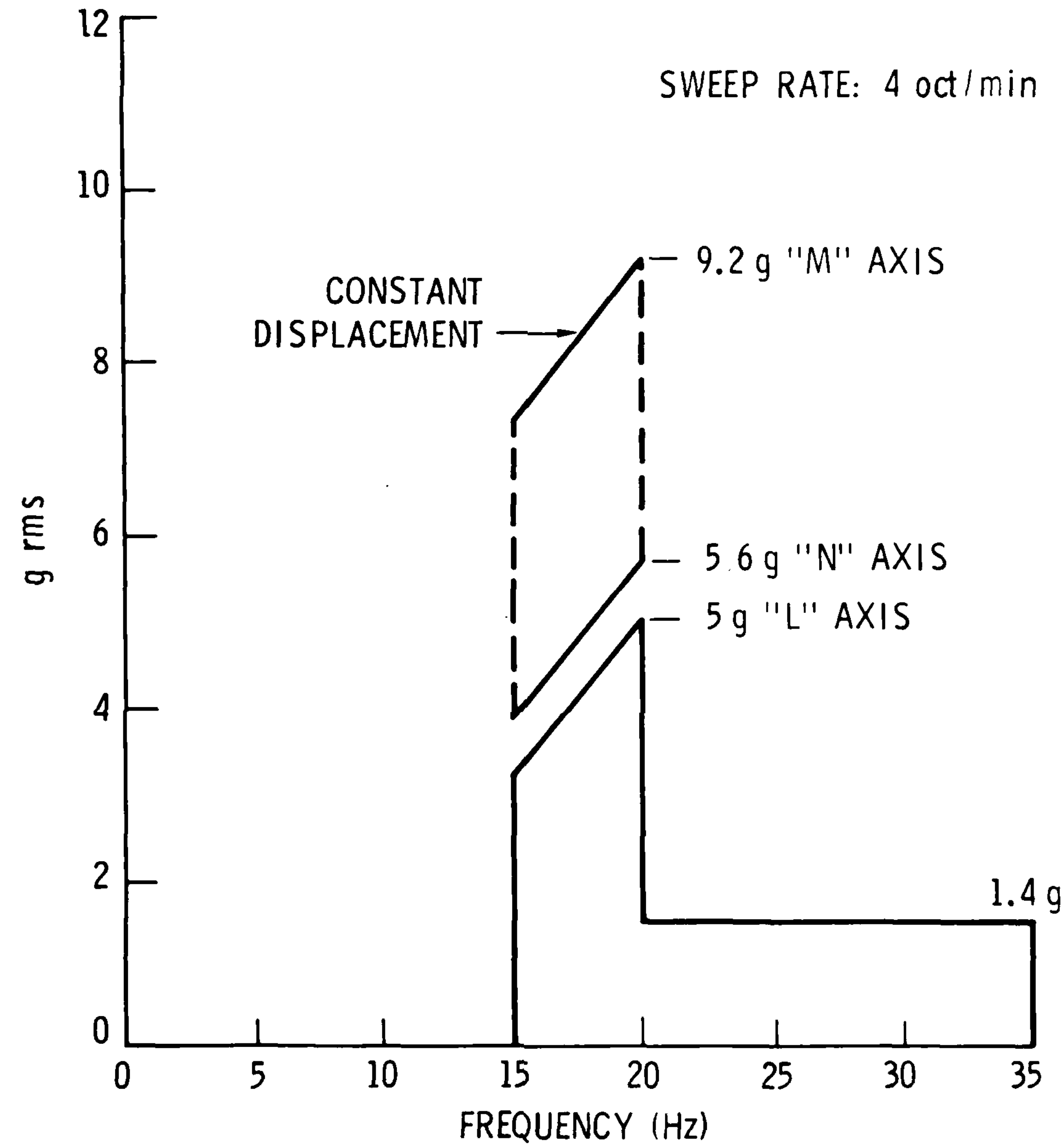


Figure 3. Sine Vibration Spectrum for Certification Acceptance

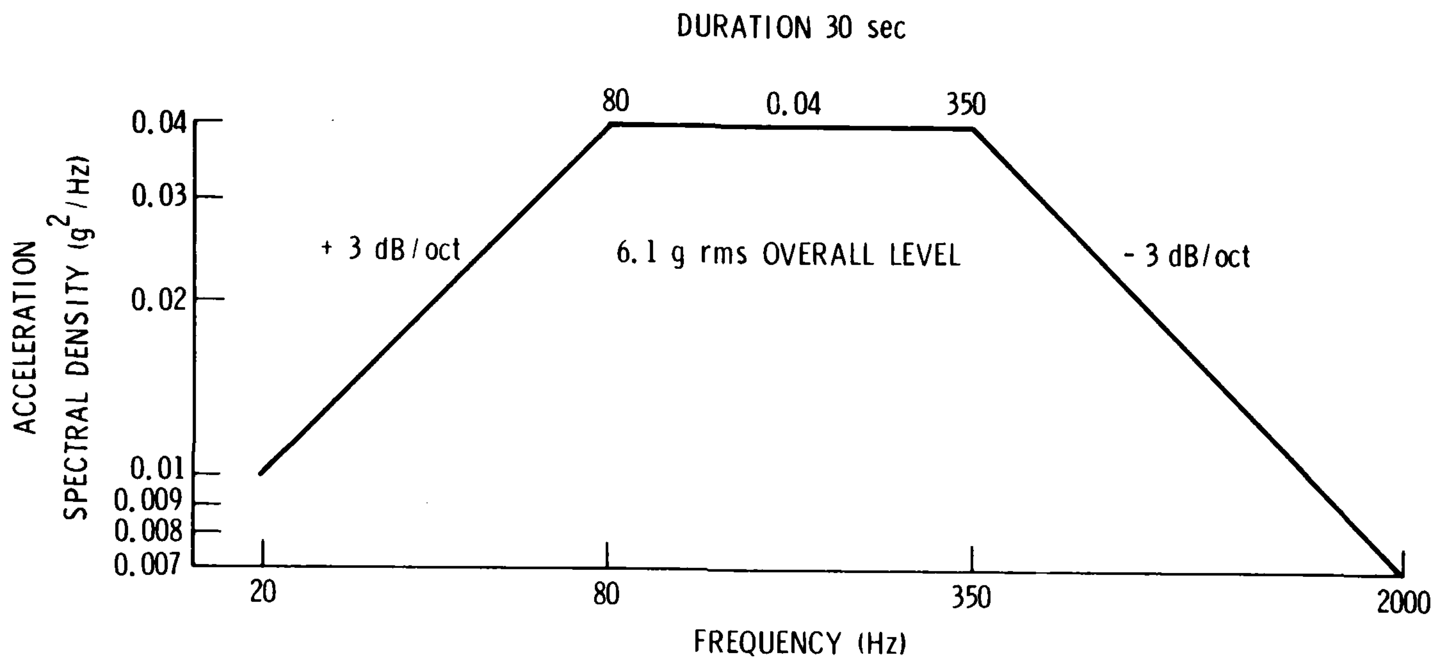


Figure 4. Random Vibration Spectrum for Certification Acceptance

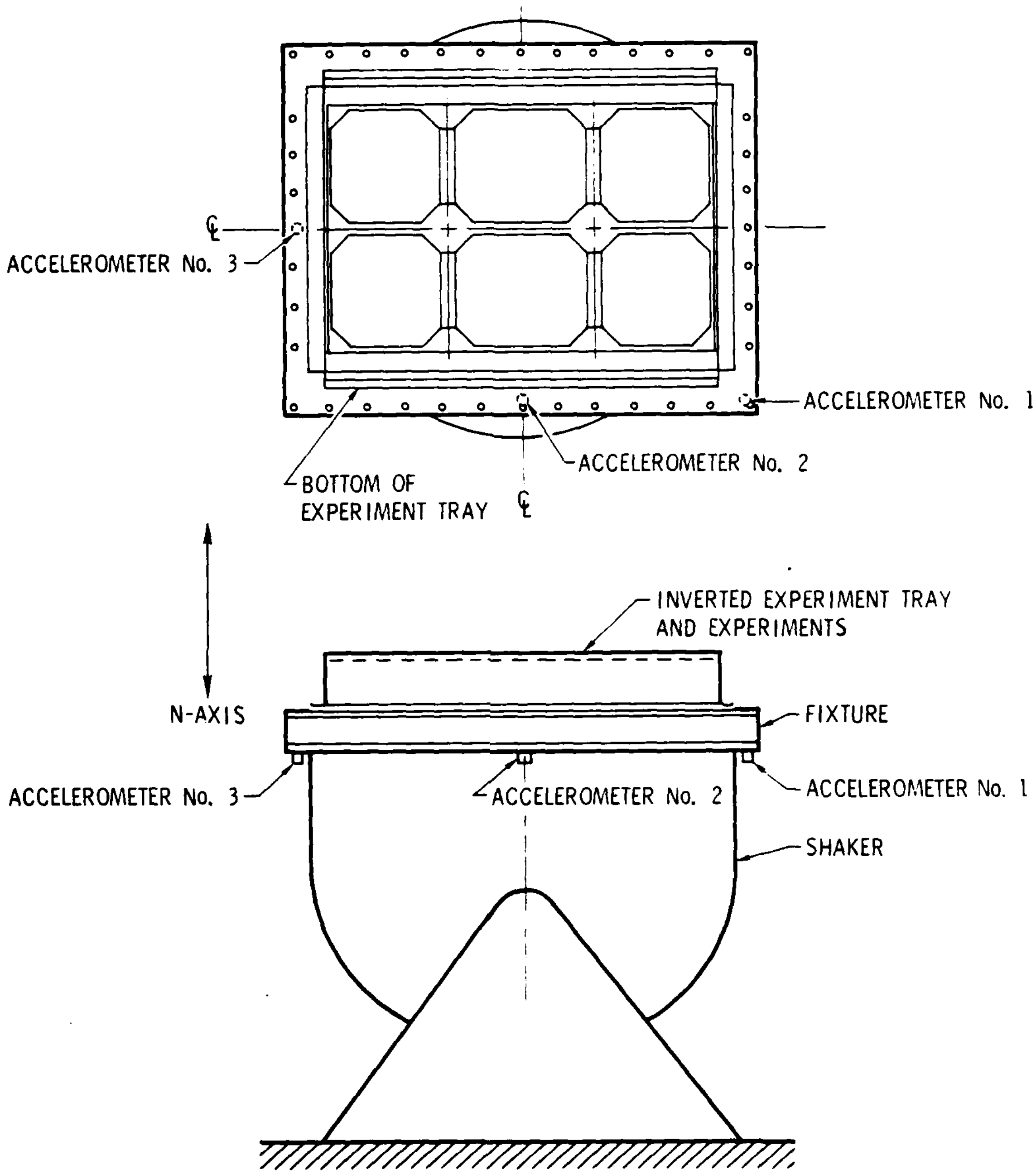


Figure 5. N-Axis Test Set Up

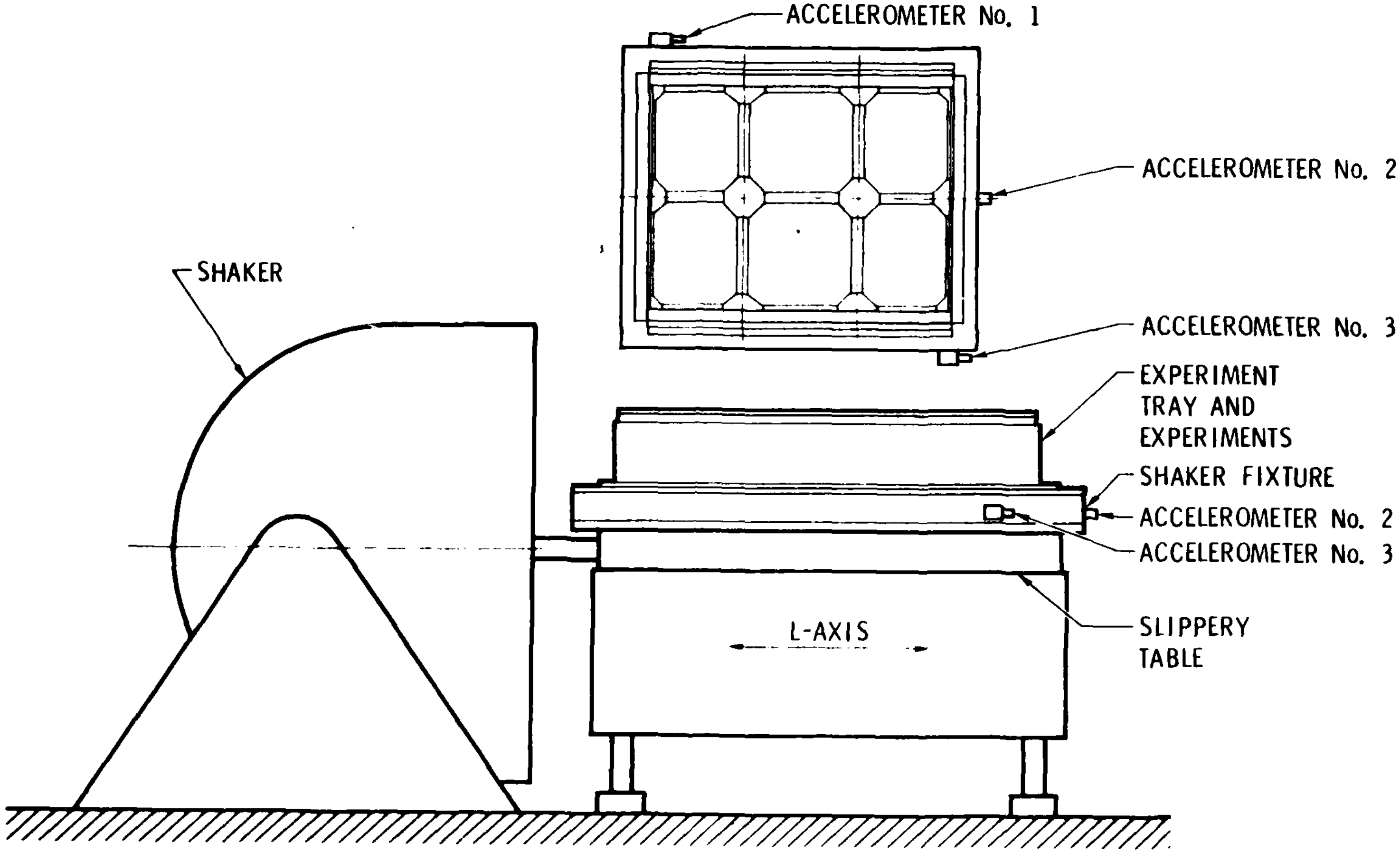


Figure 6. L-Axis Test Set Up

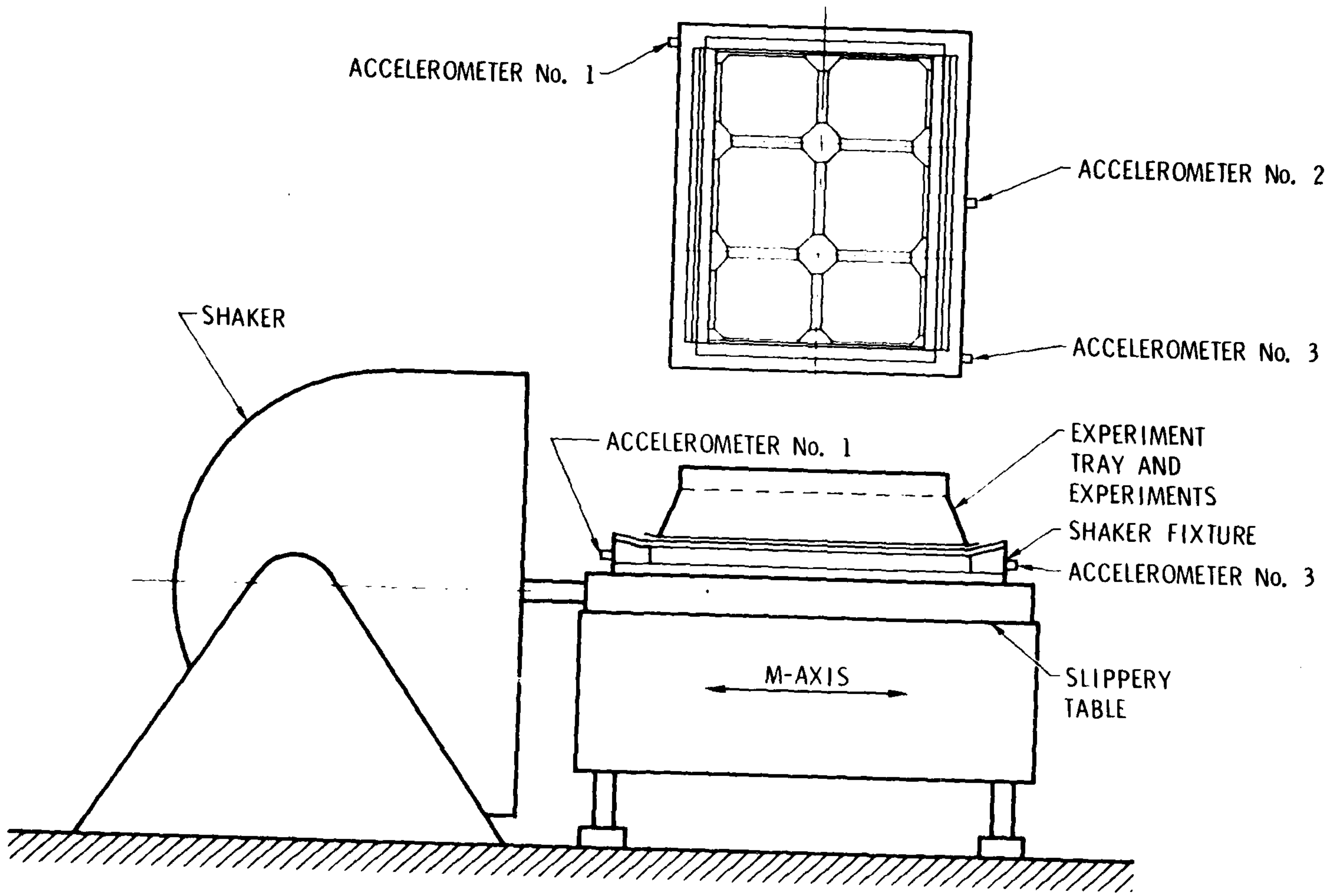
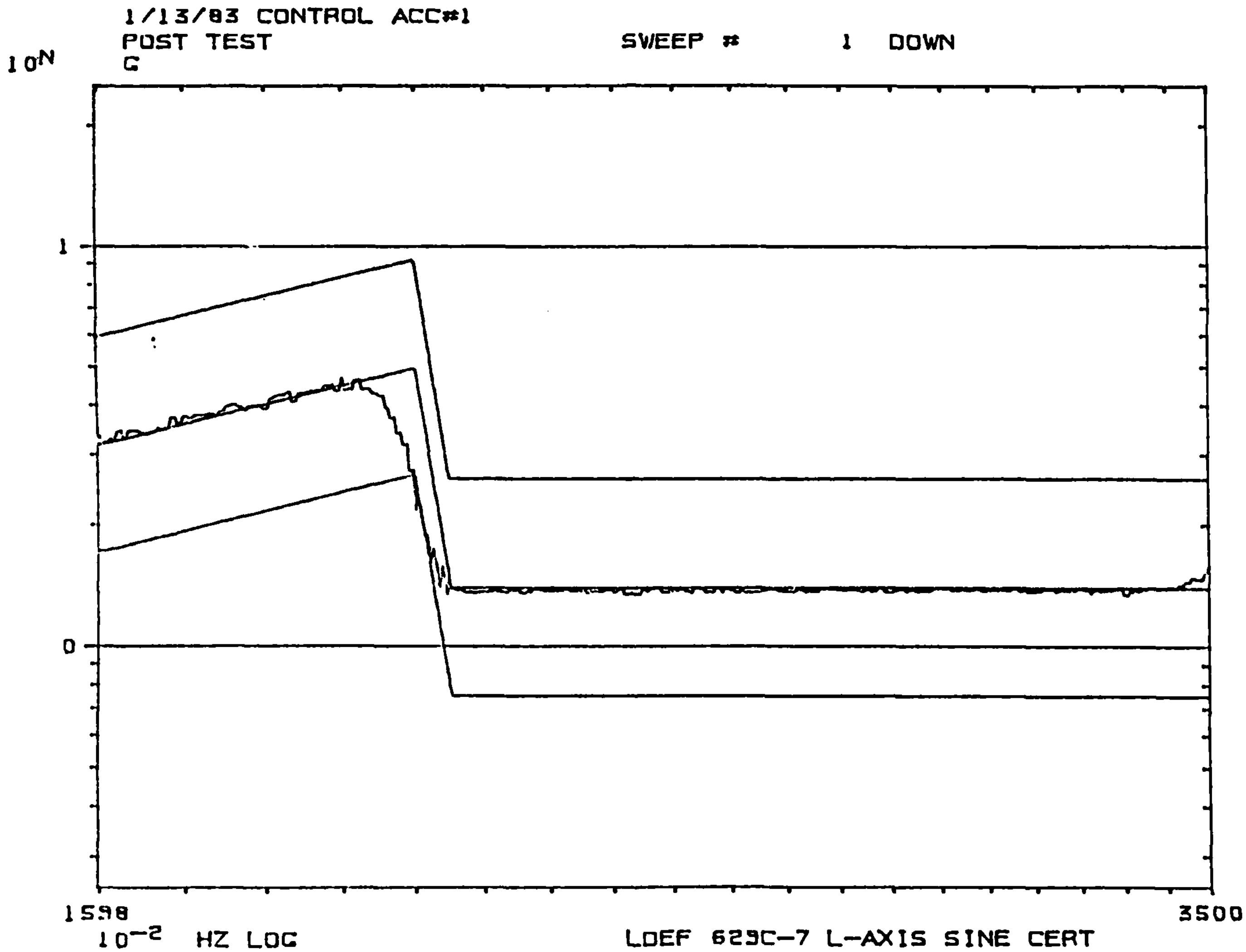


Figure 7. M-Axis Test Set Up

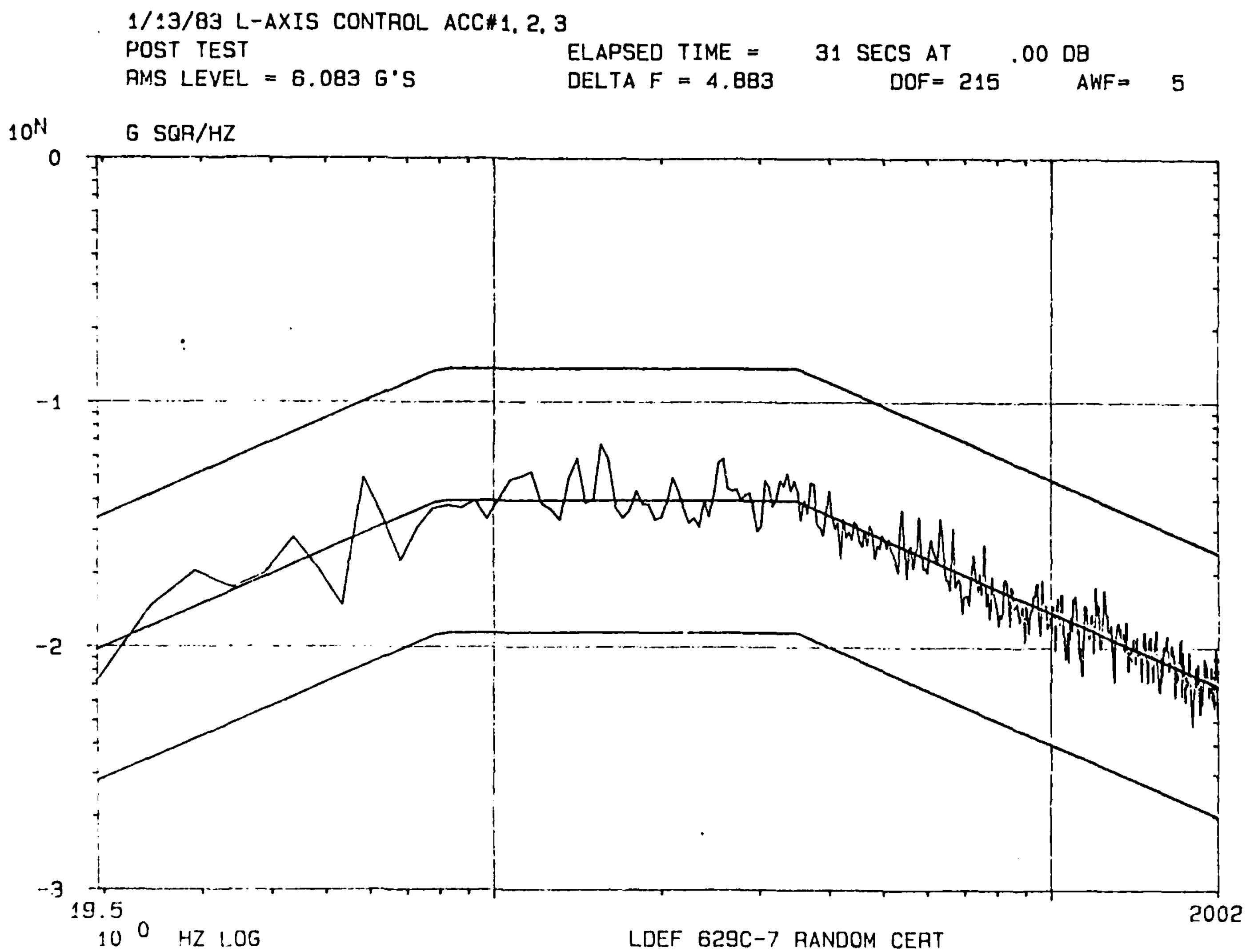
APPENDIX C

INPUT AND MONITOR ACCELEROMETER DATA



1/13/83 CONTROL ACC#1
POST TEST
C
SWEEP # 1 DOWN
10N
1
0
1598
3500
10−2 HZ LOG
LDEF 623C-7 L-AXIS SINE CERT

Fig. C-1.



1/13/83 L-AXIS CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL = 6.083 G'S
ELAPSED TIME = 31 SECS AT .00 DB
DELTA F = 4.883
DOF= 215
AWF= 5
10N
G SQR/HZ
0
-1
-2
-3
19.5
2002
10 0 HZ LOG
LDEF 629C-7 RANDOM CERT

Fig. C-2.

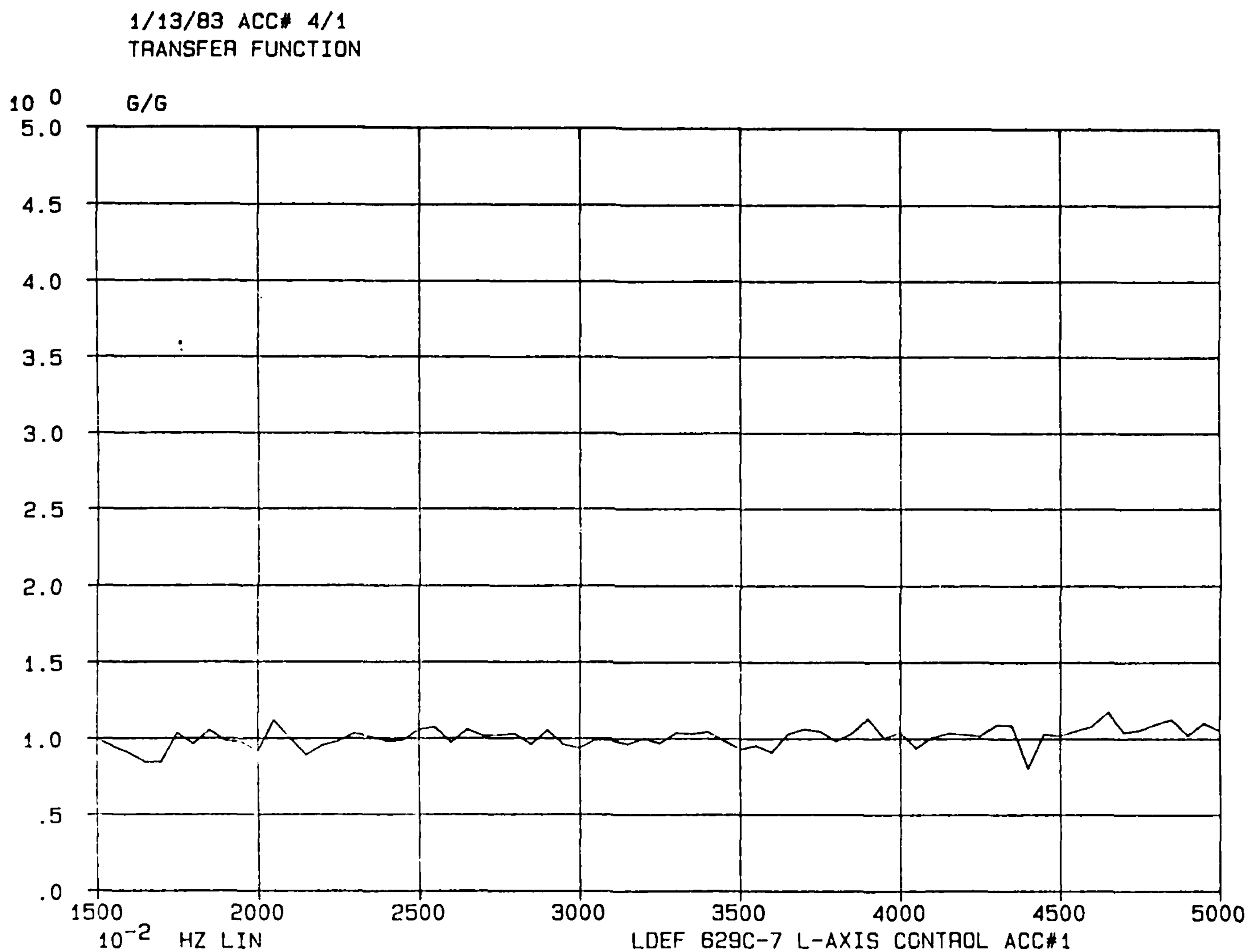
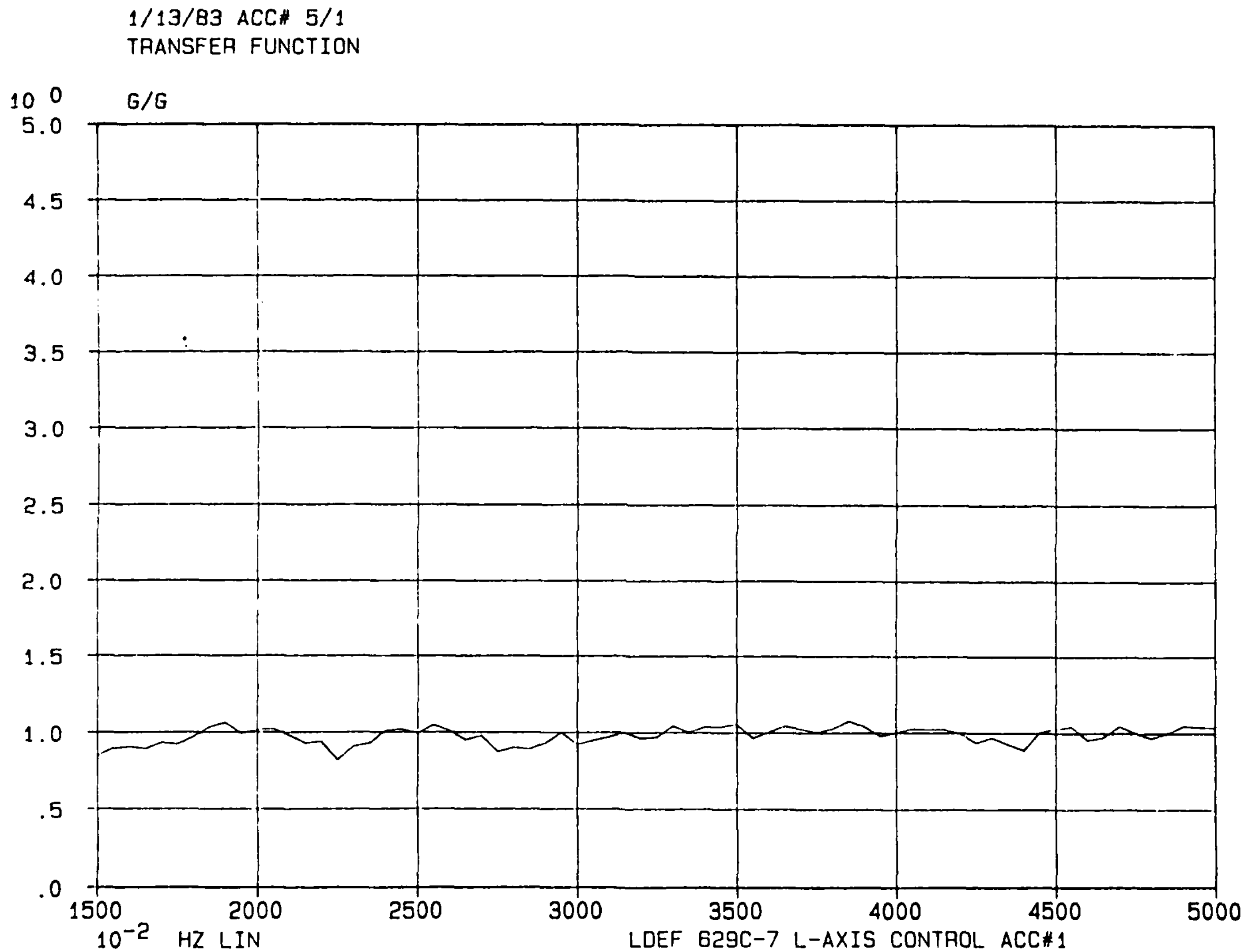

1/13/83 ACC# 4/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-7 L-AXIS CONTROL ACC#1

Fig. C-3.



1/13/83 ACC# 5/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-7 L-AXIS CONTROL ACC#1

Fig. C-4.

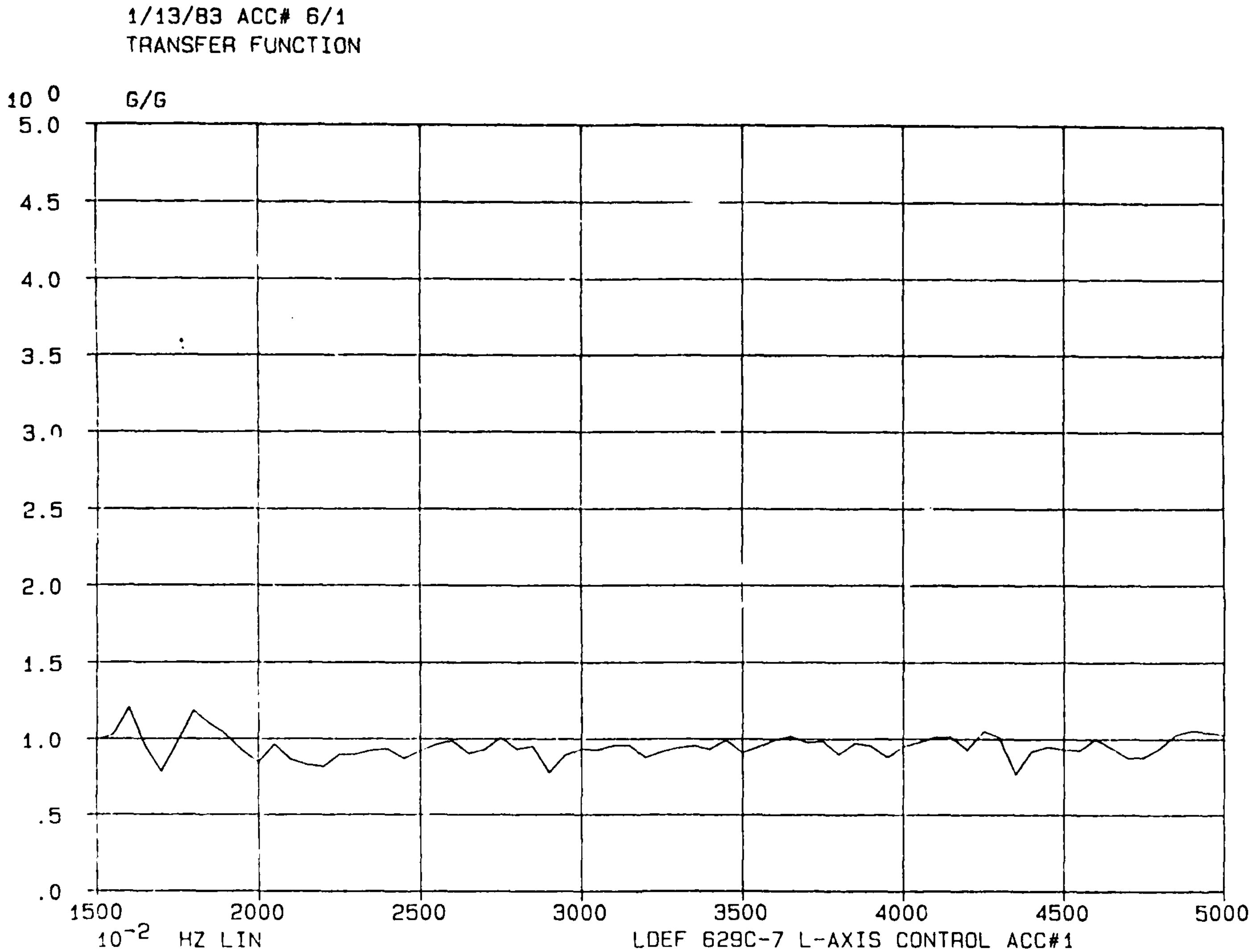

1/13/83 ACC# 6/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-7 L-AXIS CONTROL ACC#1

Fig. C-5.

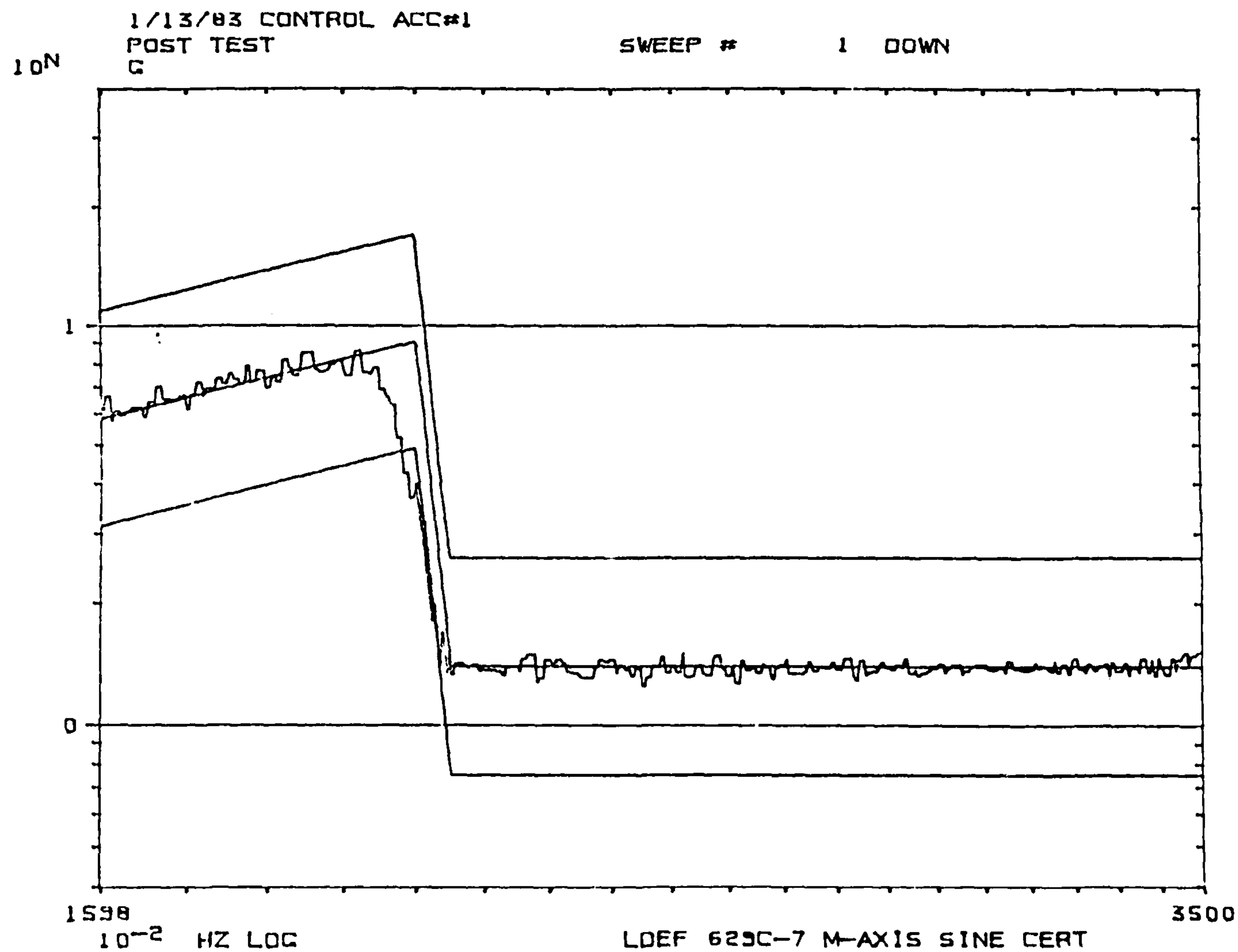

1/13/83 CONTROL ACC#1
POST TEST
G
SWEEP # 1 DOWN
10N
1
0
1598
3500
10-2 HZ LOG
LDEF 629C-7 M-AXIS SINE CERT

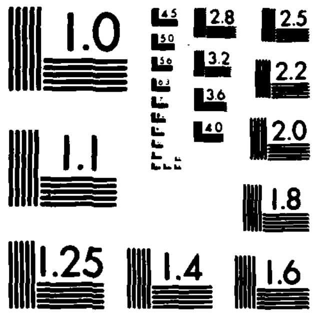
Fig. C-6.

AD-A138 547 CERTIFICATION VIBRATION TESTS SD802 MATERIALS EXPERIMENT(U) AEROSPACE CORP EL SEGUNDO CA MATERIALS SCIENCES LAB A F DIGIACOMO ET AL. 15 DEC 83

2/2

UNCLASSIFIED TR-0084(4935-05)-2 SD-TR-83-87 F/G 14/2 NL

END
DATE
FILMED
4 84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

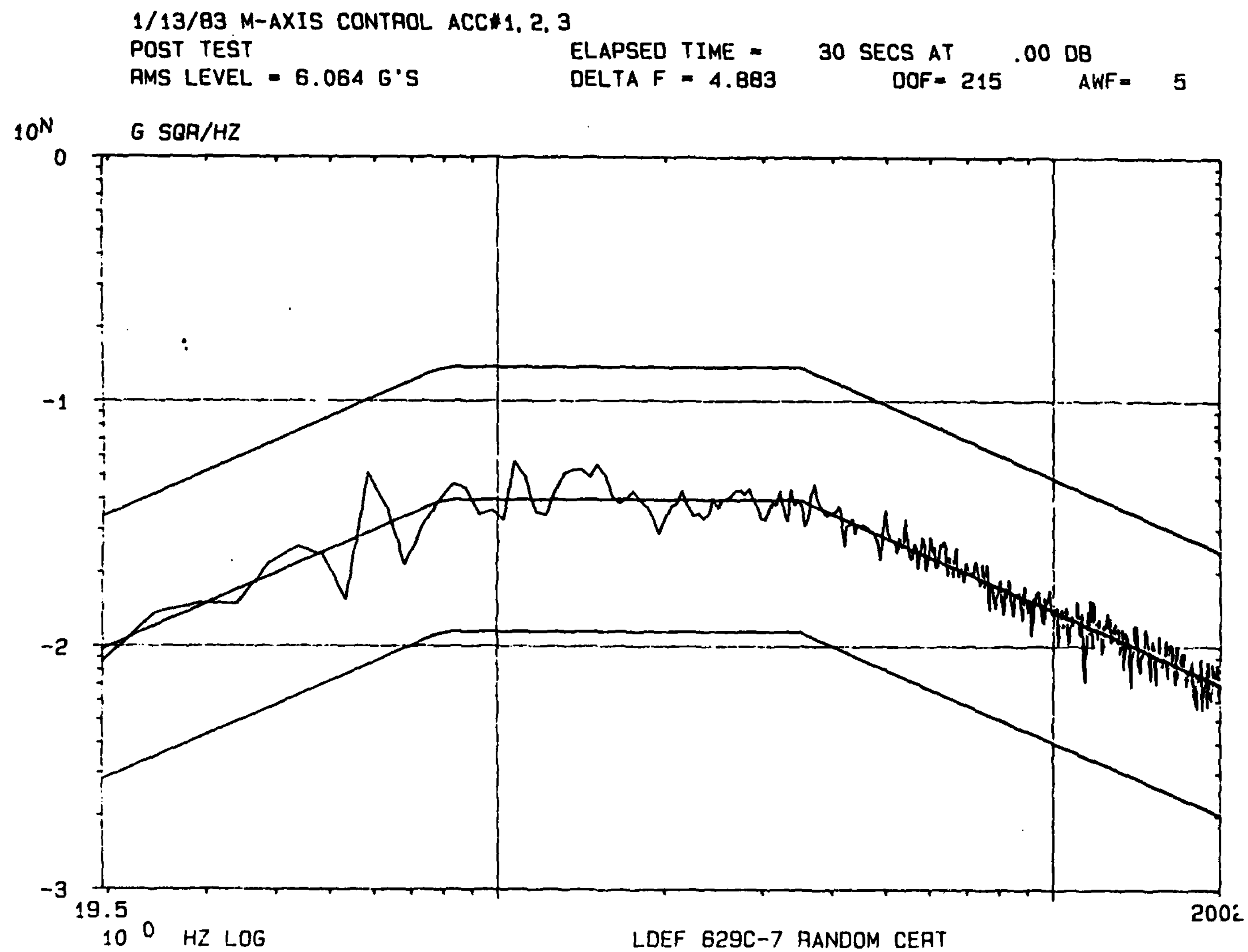

1/13/83 M-AXIS CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL = 6.064 G'S
ELAPSED TIME = 30 SECS AT .00 DB
DELTA F = 4.883 DOF= 215 AWF= 5
10N G SQR/HZ
0
-1
-2
-3
19.5
10 0 HZ LOG
LDEF 629C-7 RANDOM CERT

Fig. C-7.

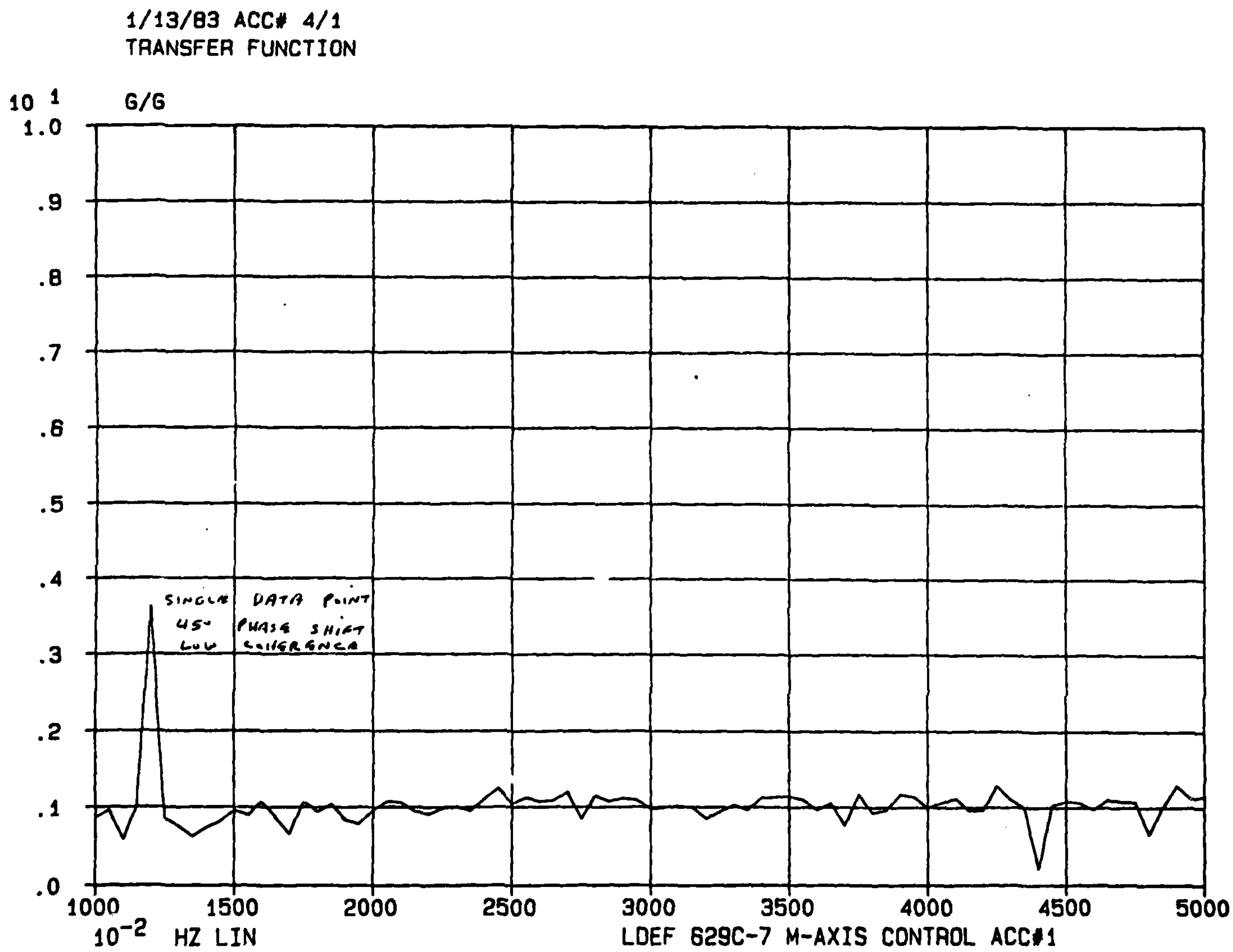

1/13/83 ACC# 4/1
TRANSFER FUNCTION
10 1
G/G
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
SINGLE DATA POINT
45° PHASE SHIFT
LOW COHERENCE
1000
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-7 M-AXIS CONTROL ACC#1

Fig. C-8.

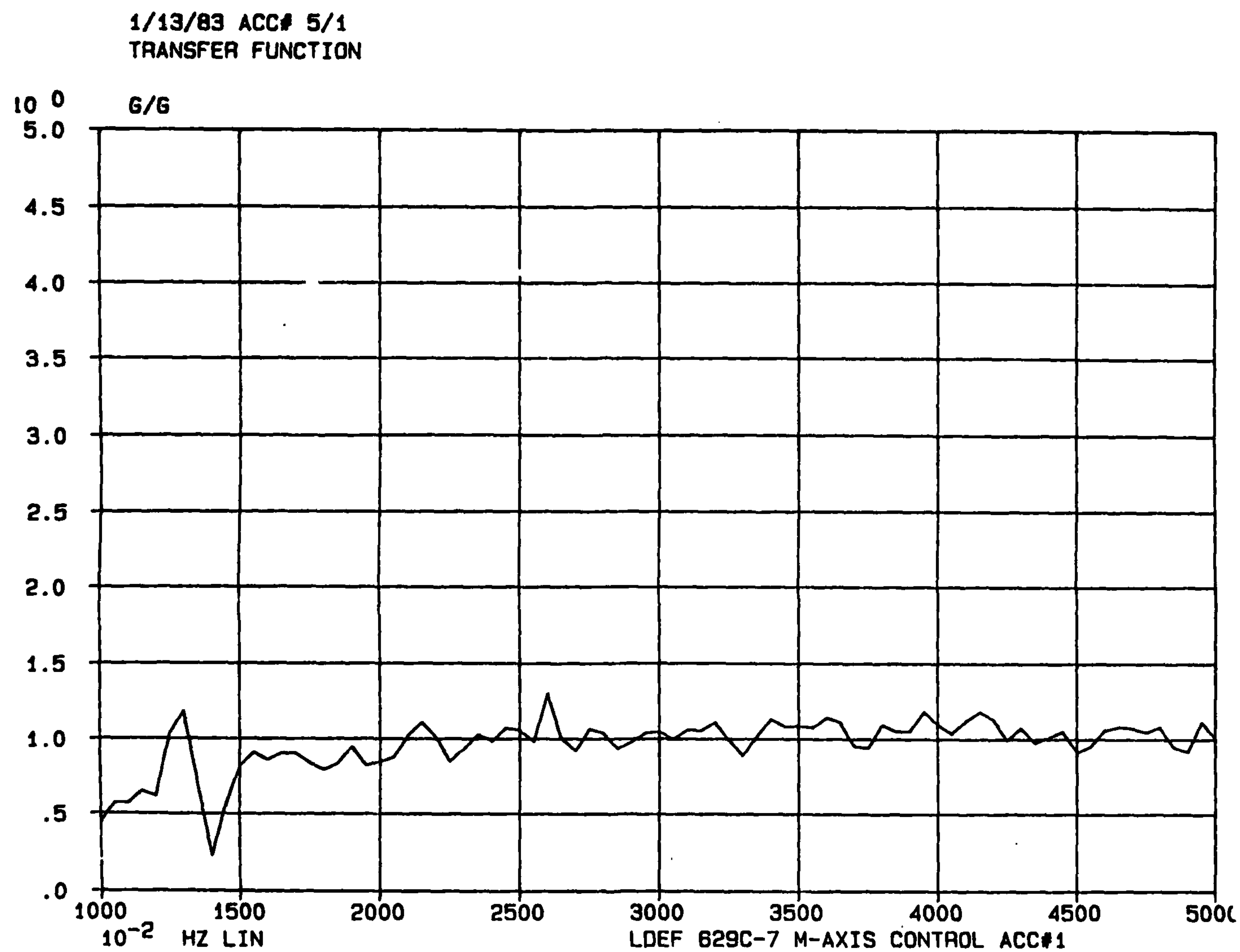

1/13/83 ACC# 5/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1000
1500
2000
2500
3000
3500
4000
4500
500(
10-2 HZ LIN
LDEF 629C-7 M-AXIS CONTROL ACC#1

Fig. C-9.

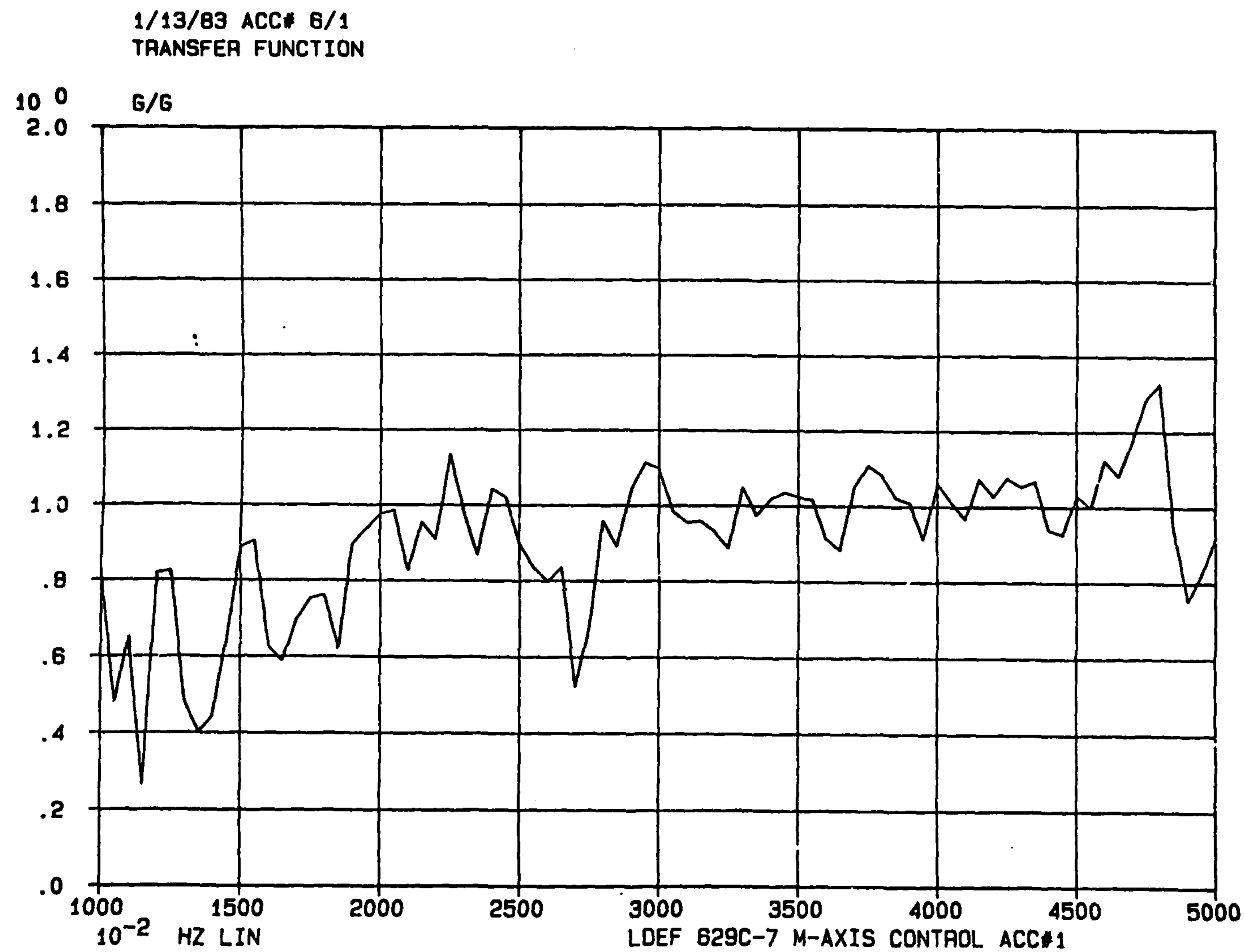
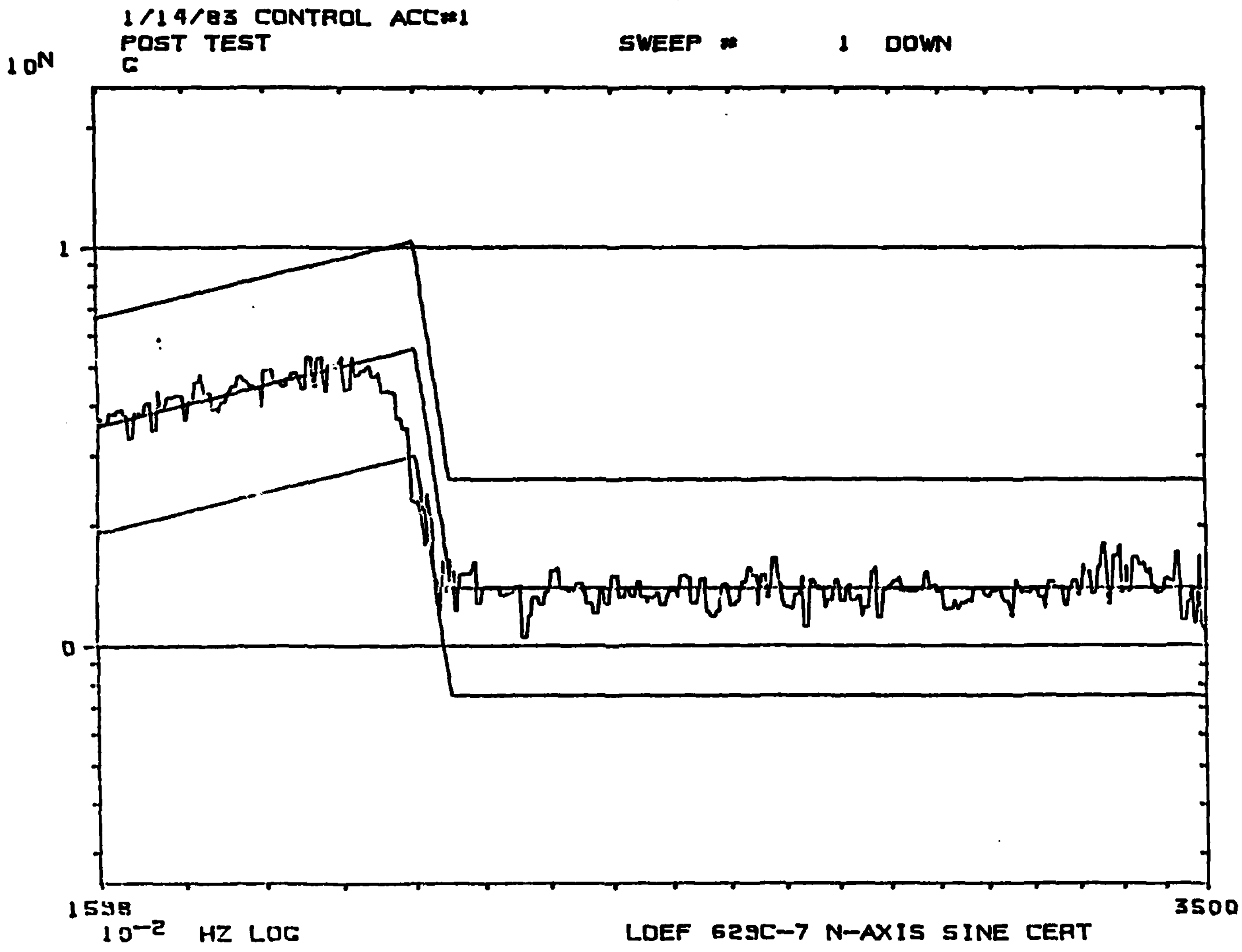

1/13/83 ACC# 6/1
TRANSFER FUNCTION
10 0
G/G
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
1000
1500
2000
2500
3000
3500
4000
4500
5000
10^{-2} HZ LIN
LDEF 629C-7 M-AXIS CONTROL ACC#1

Fig. C-10.



1/14/83 CONTROL ACC#1
POST TEST
C
SWEEP # 1 DOWN
10^N
1
0
1598
10^-2 HZ LOG
3500
LDEF 629C-7 N-AXIS SINE CERT

Fig. C-11.

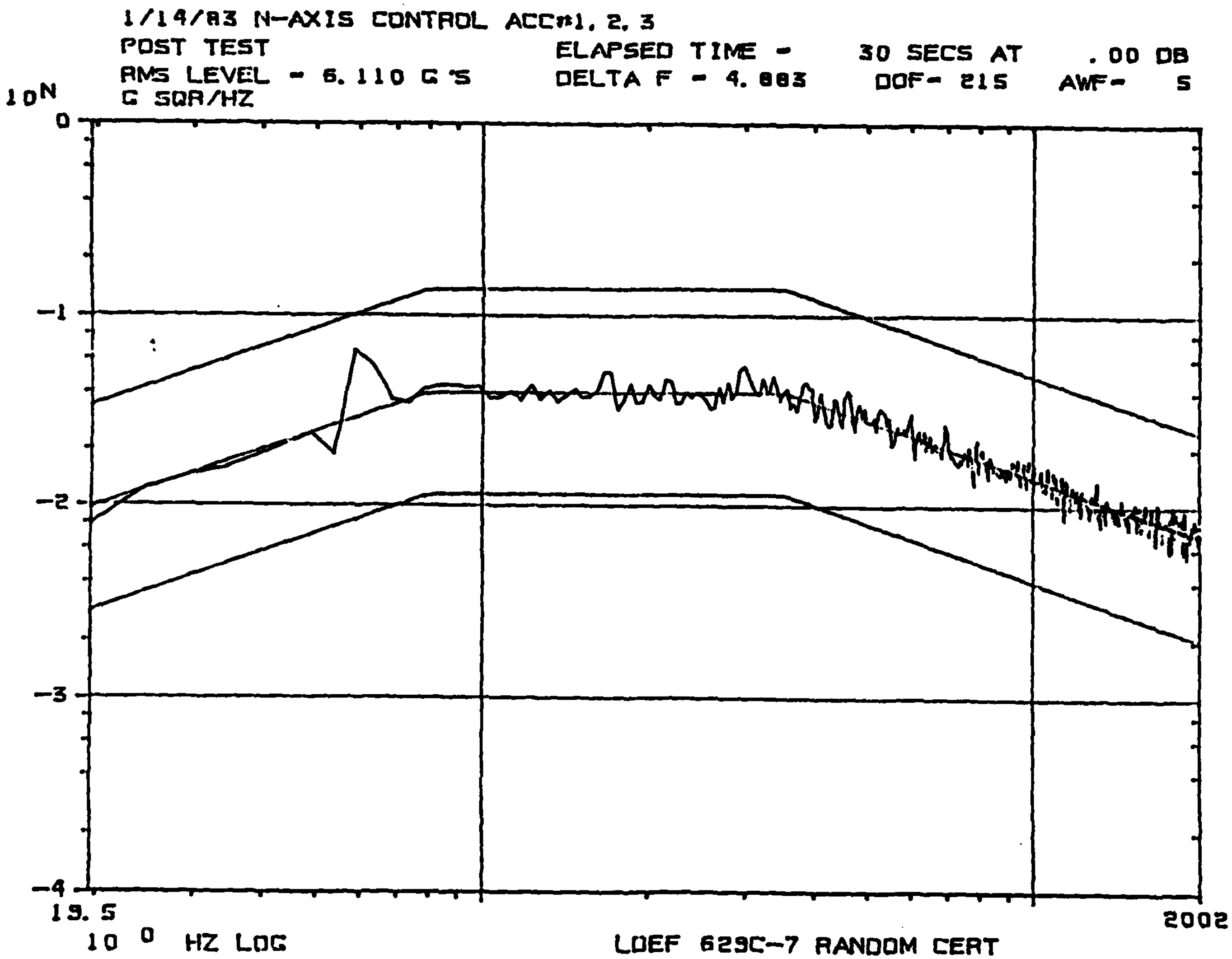

1/14/83 N-AXIS CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL - 6.110 G'S
G SQR/HZ
ELAPSED TIME - 30 SECS AT .00 DB
DELTA F - 4.883 DOF- 215 AWF- 5
10^N
0
-1
-2
-3
-4
19.5
2002
10 0 HZ LOG
LOEF 629C-7 RANDOM CERT

Fig. C-12.

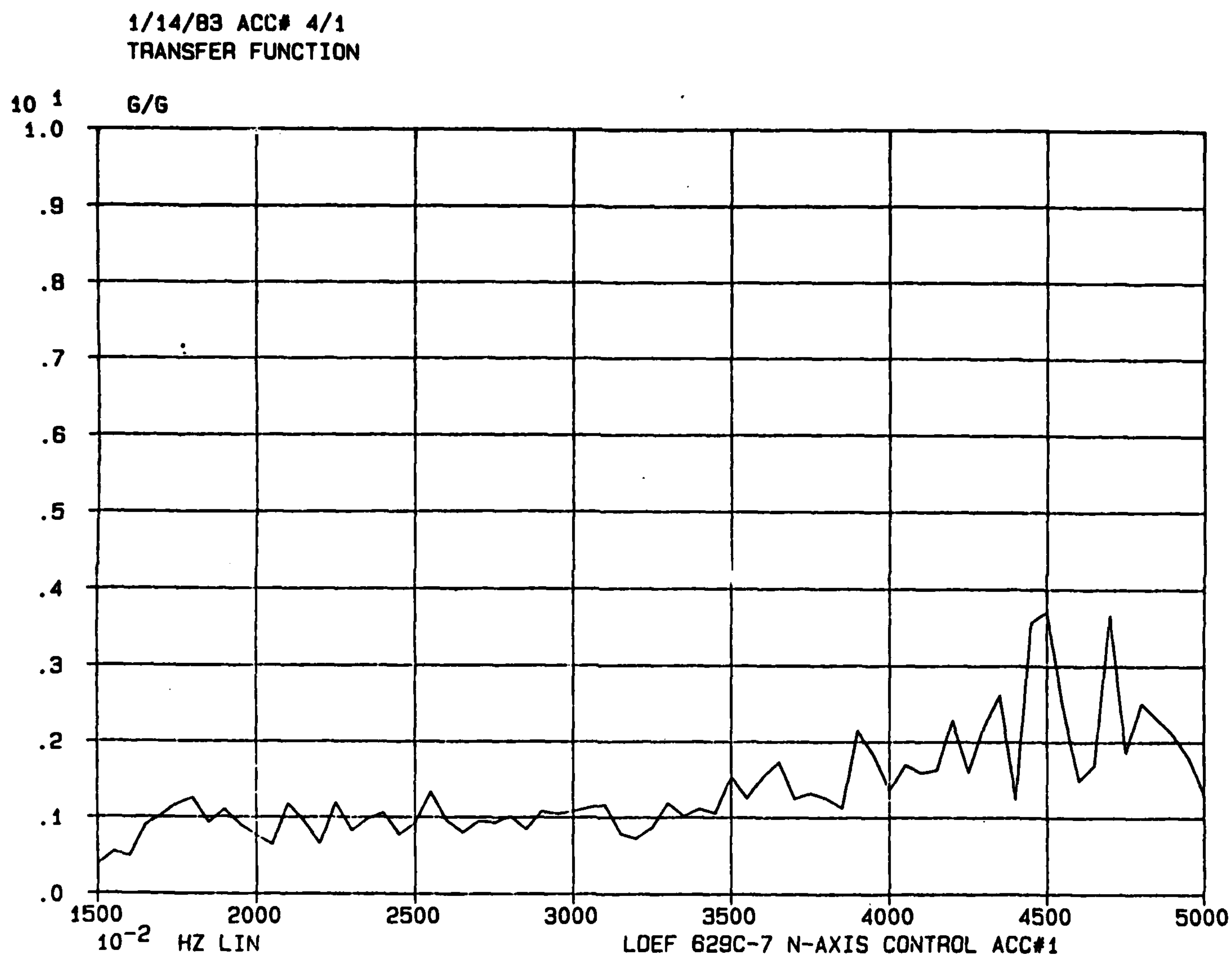

1/14/83 ACC# 4/1
TRANSFER FUNCTION
10 1
G/G
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
1500
2000
2500
3000
3500
4000
4500
5000
10^-2 HZ LIN
LDEF 629C-7 N-AXIS CONTROL ACC#1

Fig. C-13.

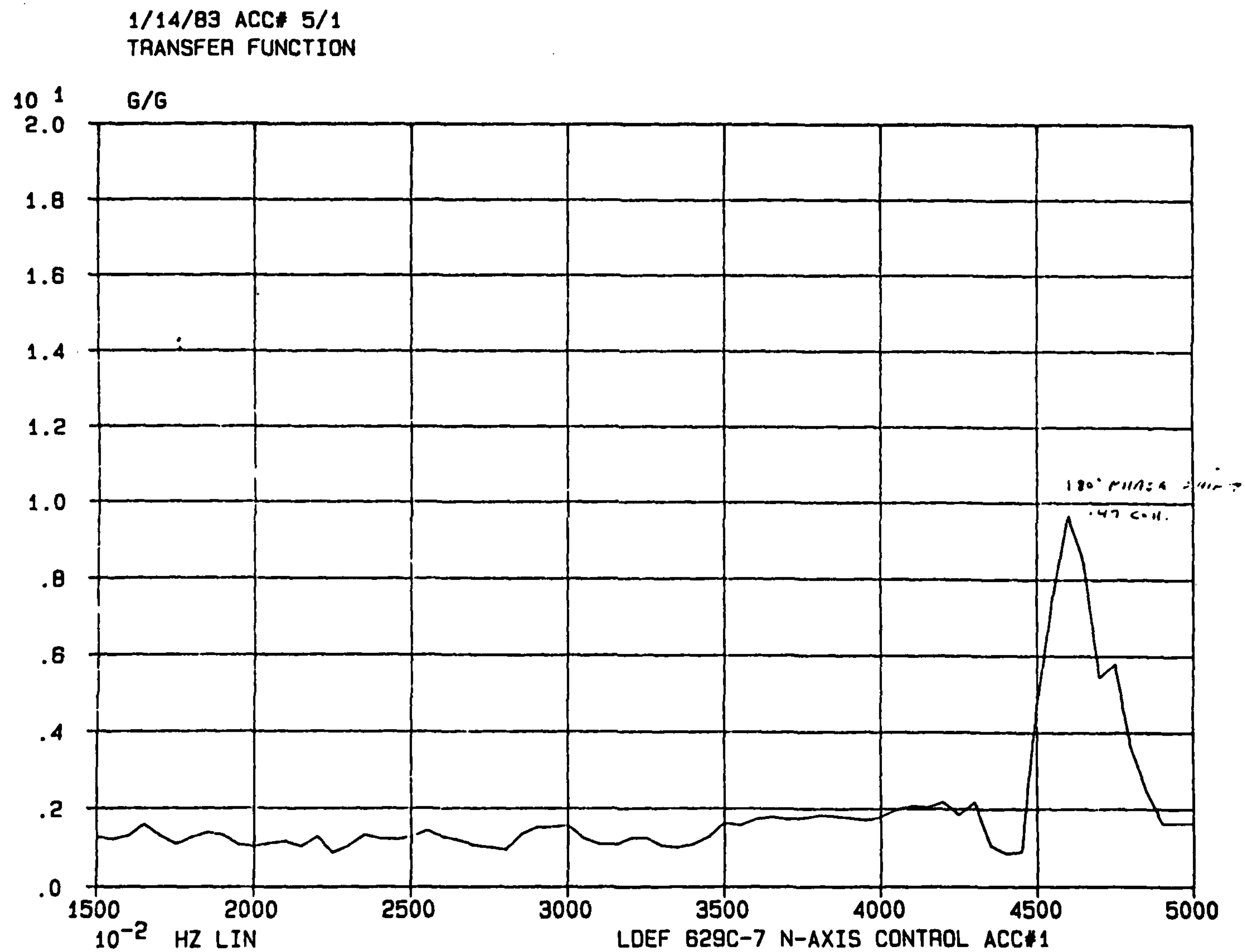

1/14/83 ACC# 5/1
TRANSFER FUNCTION
G/G
10 1
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-7 N-AXIS CONTROL ACC#1

Fig. C-14.

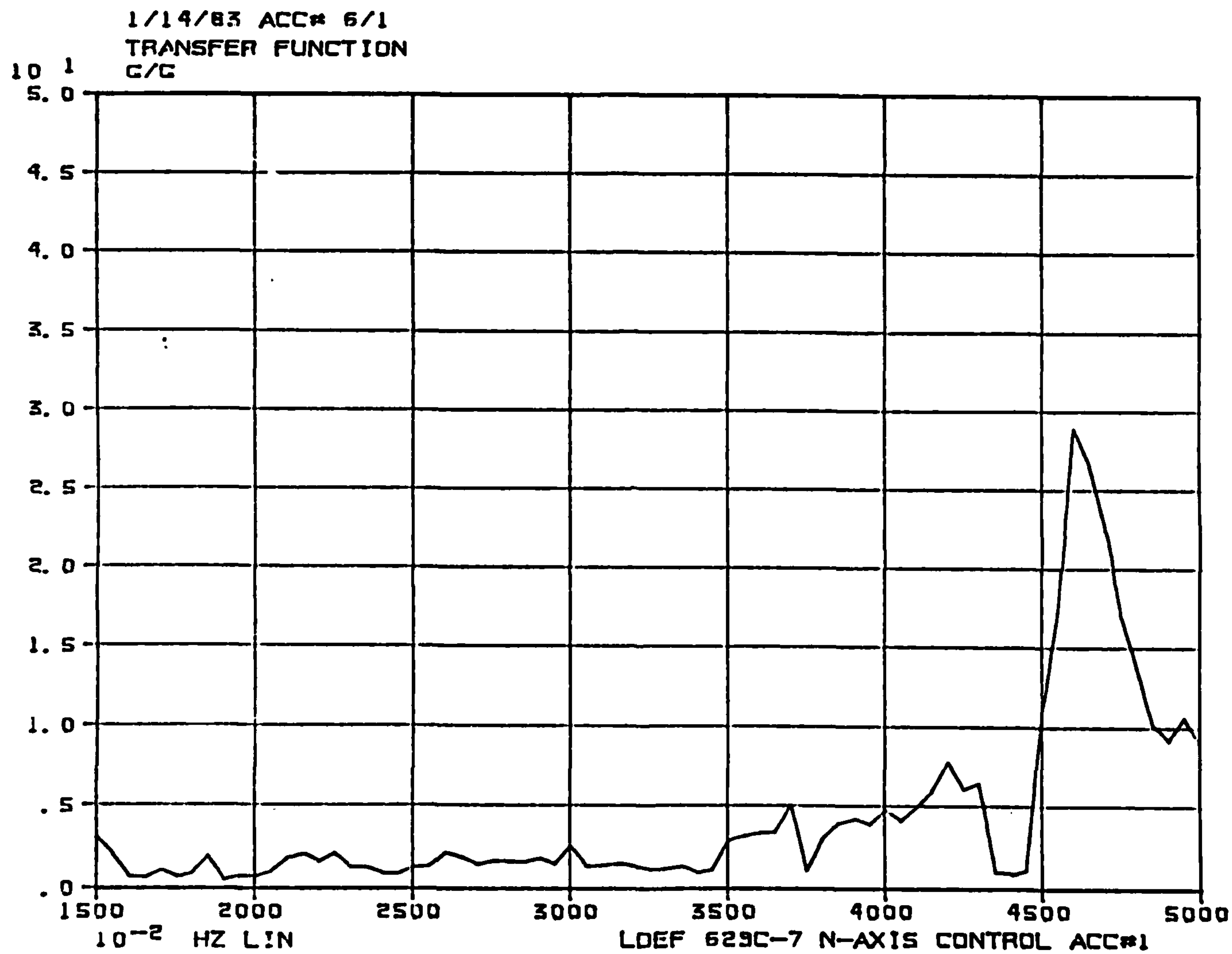

1/14/83 ACC# 6/1
TRANSFER FUNCTION
G/G
10 1
5. 0
4. 5
4. 0
3. 5
3. 0
2. 5
2. 0
1. 5
1. 0
. 5
. 0
1500
2000
2500
3000
3500
4000
4500
5000
10−2 HZ LIN
LDEF 629C-7 N-AXIS CONTROL ACC#1

Fig. C-15.

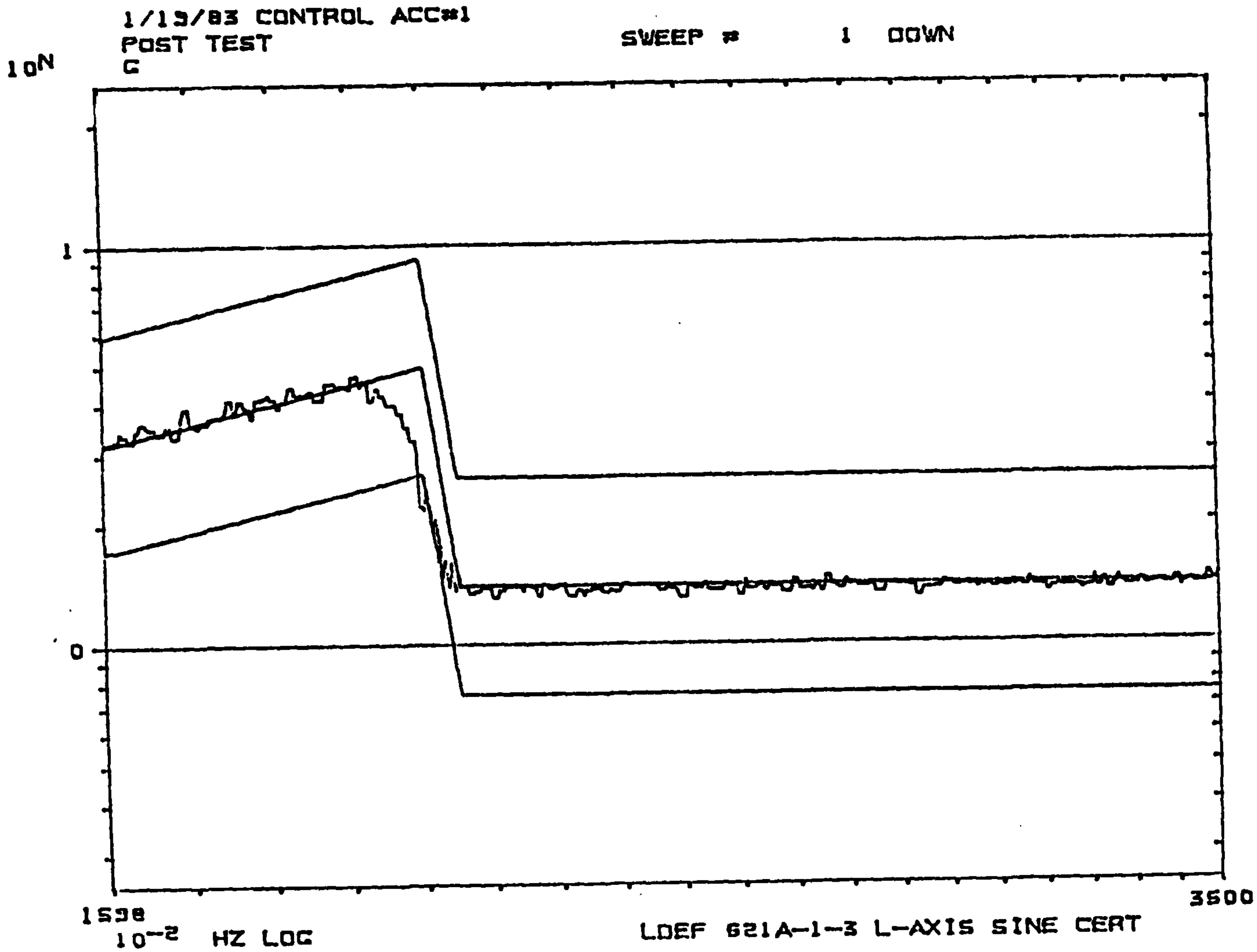

1/13/83 CONTROL ACC#1
POST TEST
G
SWEEP # 1 DOWN
10N
1
0
1538
10-2 HZ LOG
3500
LDEF 621A-1-3 L-AXIS SINE CERT

Fig. C-16.

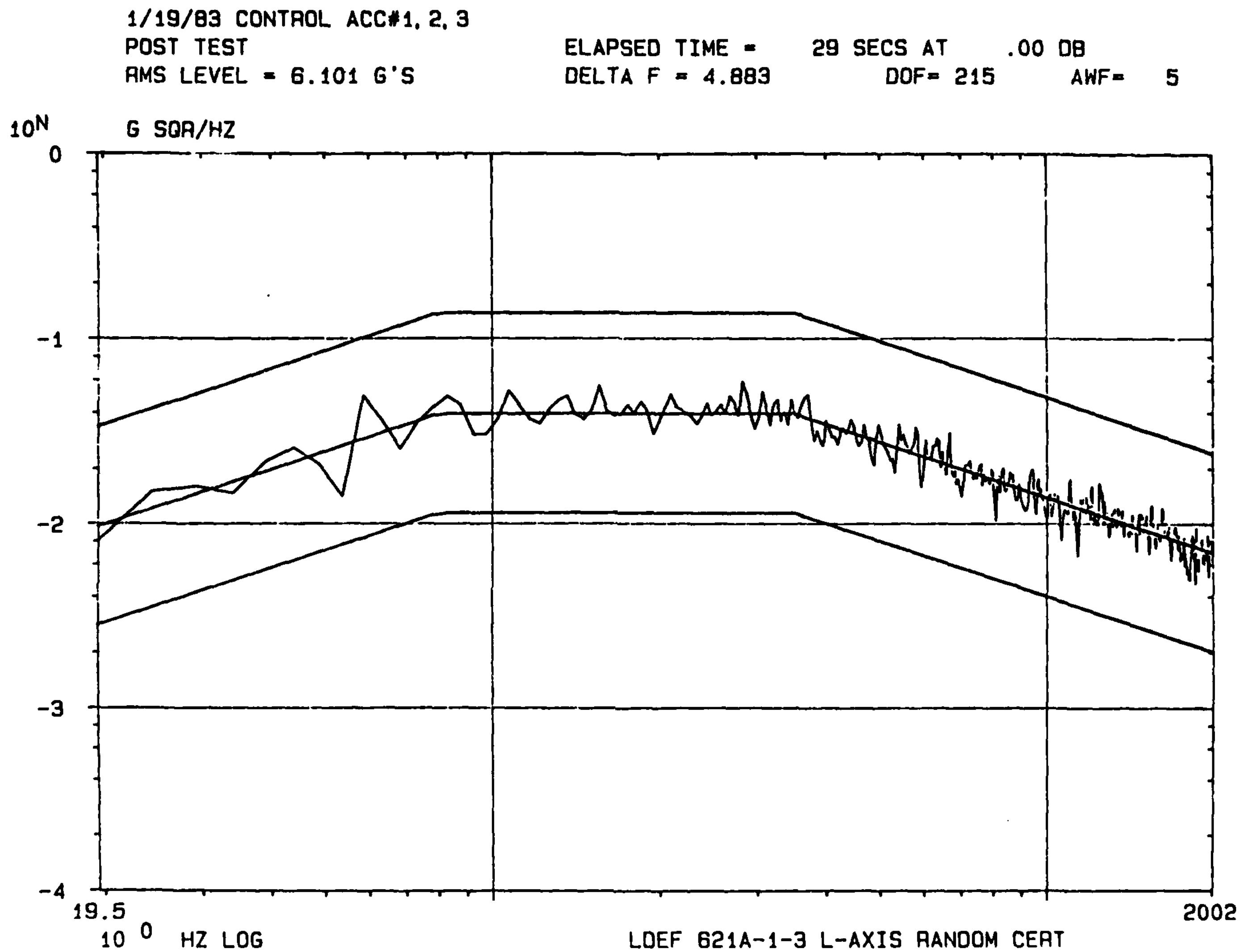
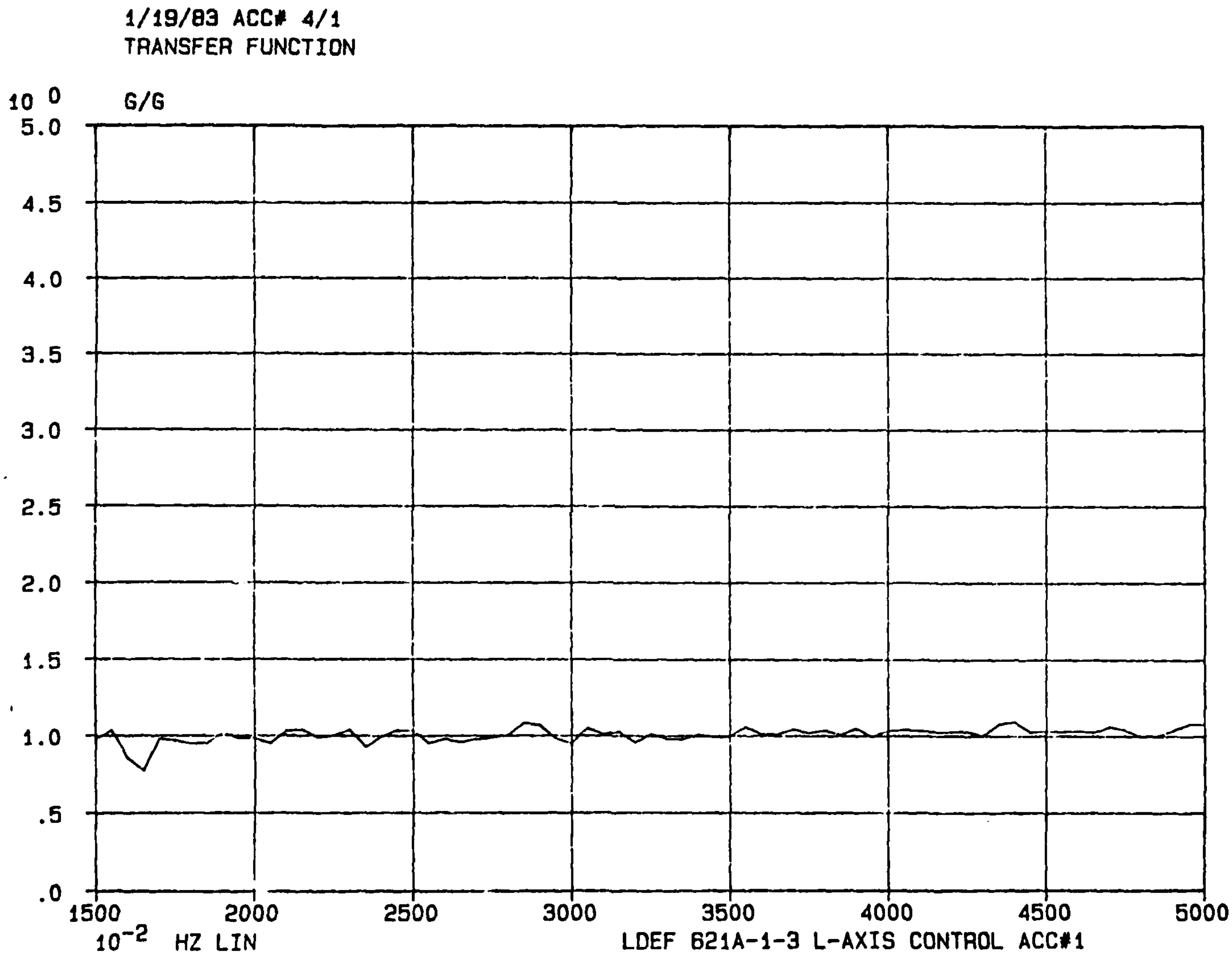

1/19/83 CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL = 6.101 G'S
ELAPSED TIME = 29 SECS AT .00 DB
DELTA F = 4.883
DOF= 215
AWF= 5
10N
G SQR/HZ
0
-1
-2
-3
-4
19.5
2002
10 0
HZ LOG
LDEF 621A-1-3 L-AXIS RANDOM CERT

Fig. C-17.



1/19/83 ACC# 4/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 621A-1-3 L-AXIS CONTROL ACC#1

Fig. C-18.

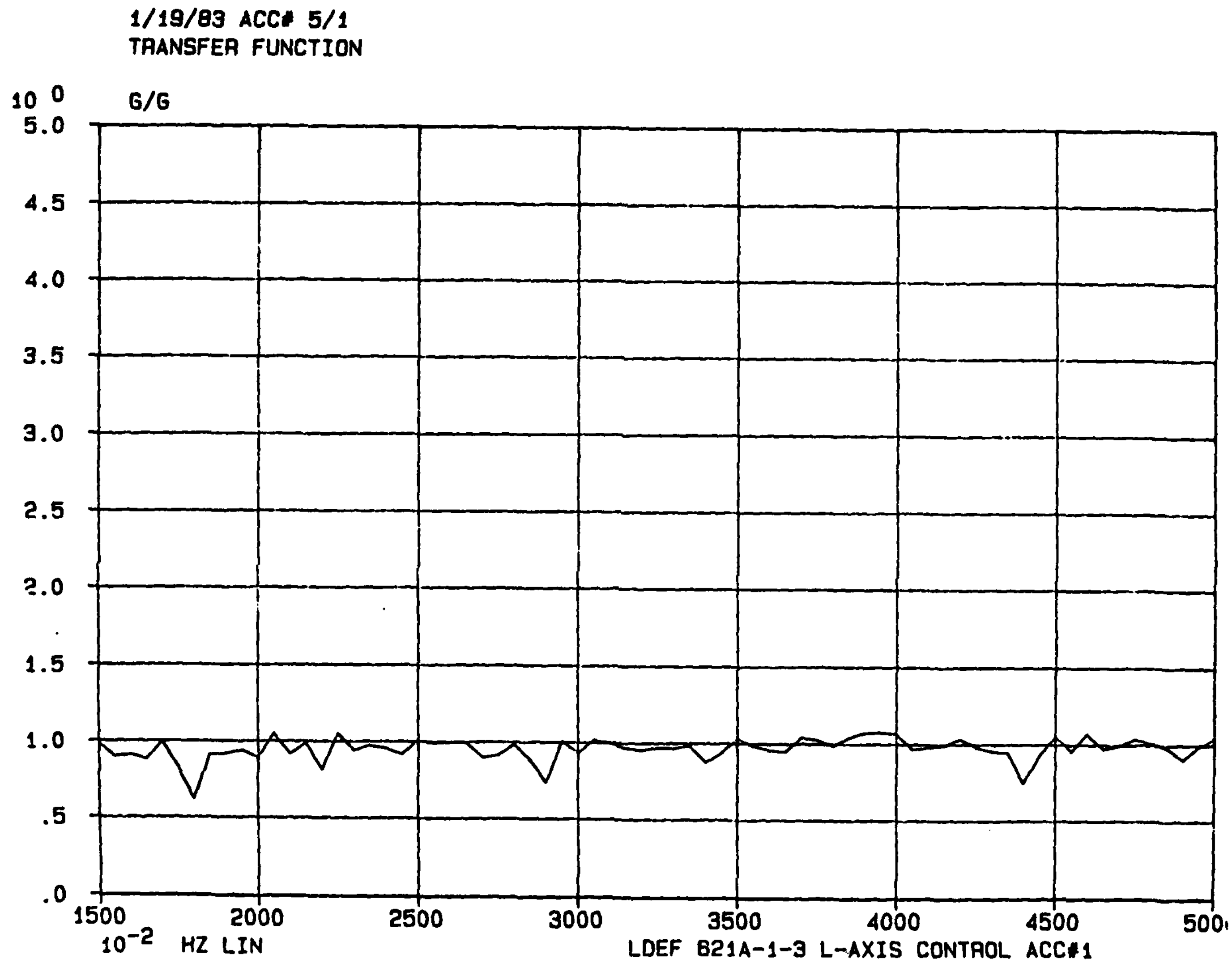

1/19/83 ACC# 5/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 621A-1-3 L-AXIS CONTROL ACC#1

Fig. C-19.

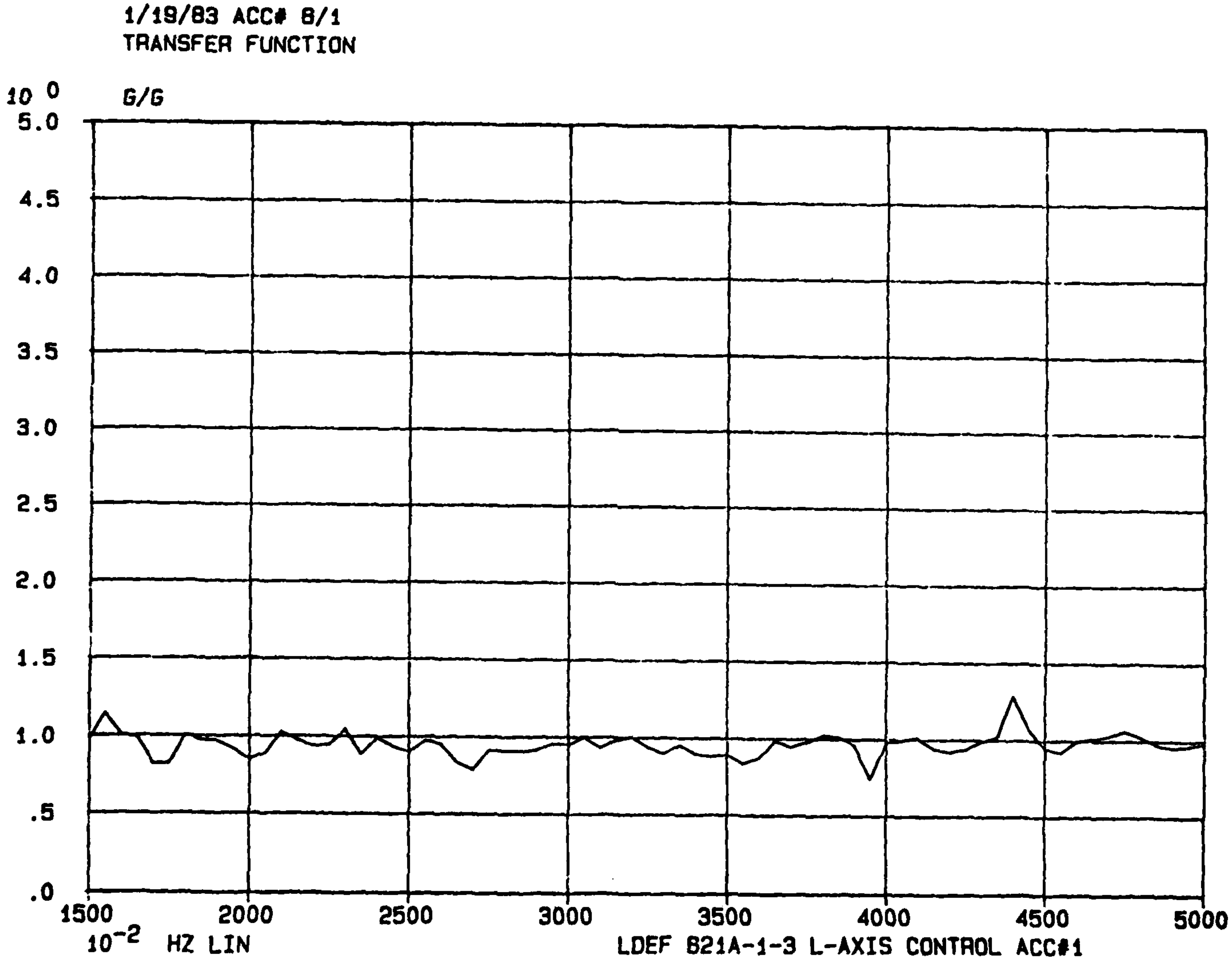

1/19/83 ACC# 8/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF B21A-1-3 L-AXIS CONTROL ACC#1

Fig. C-20.

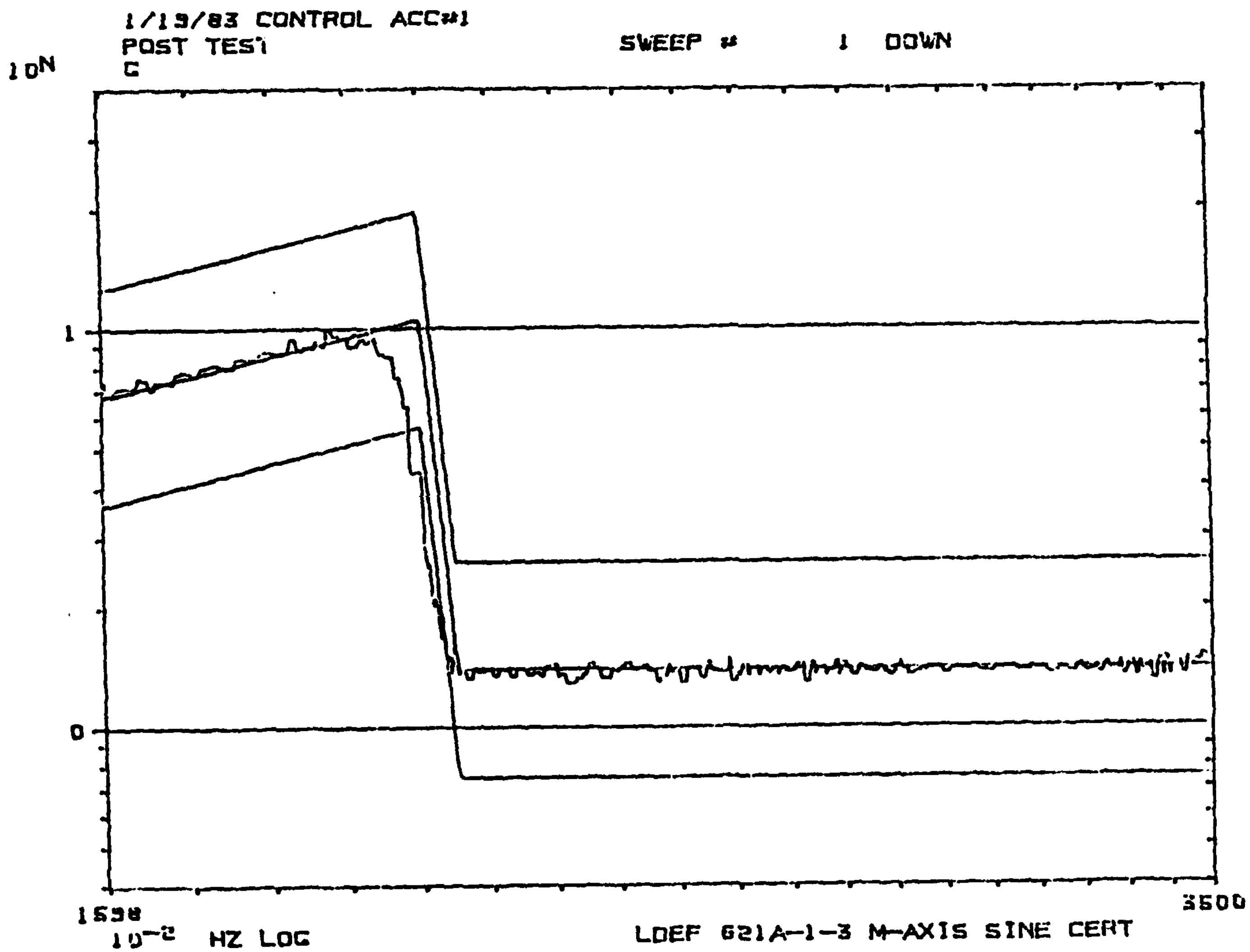

1/19/83 CONTROL ACC#1
POST TEST
C
SWEEP # 1 DOWN
10N
1
0
1598
10-2 HZ LOG
3500
LDEF 621A-1-3 M-AXIS SINE CERT

Fig. C-21.

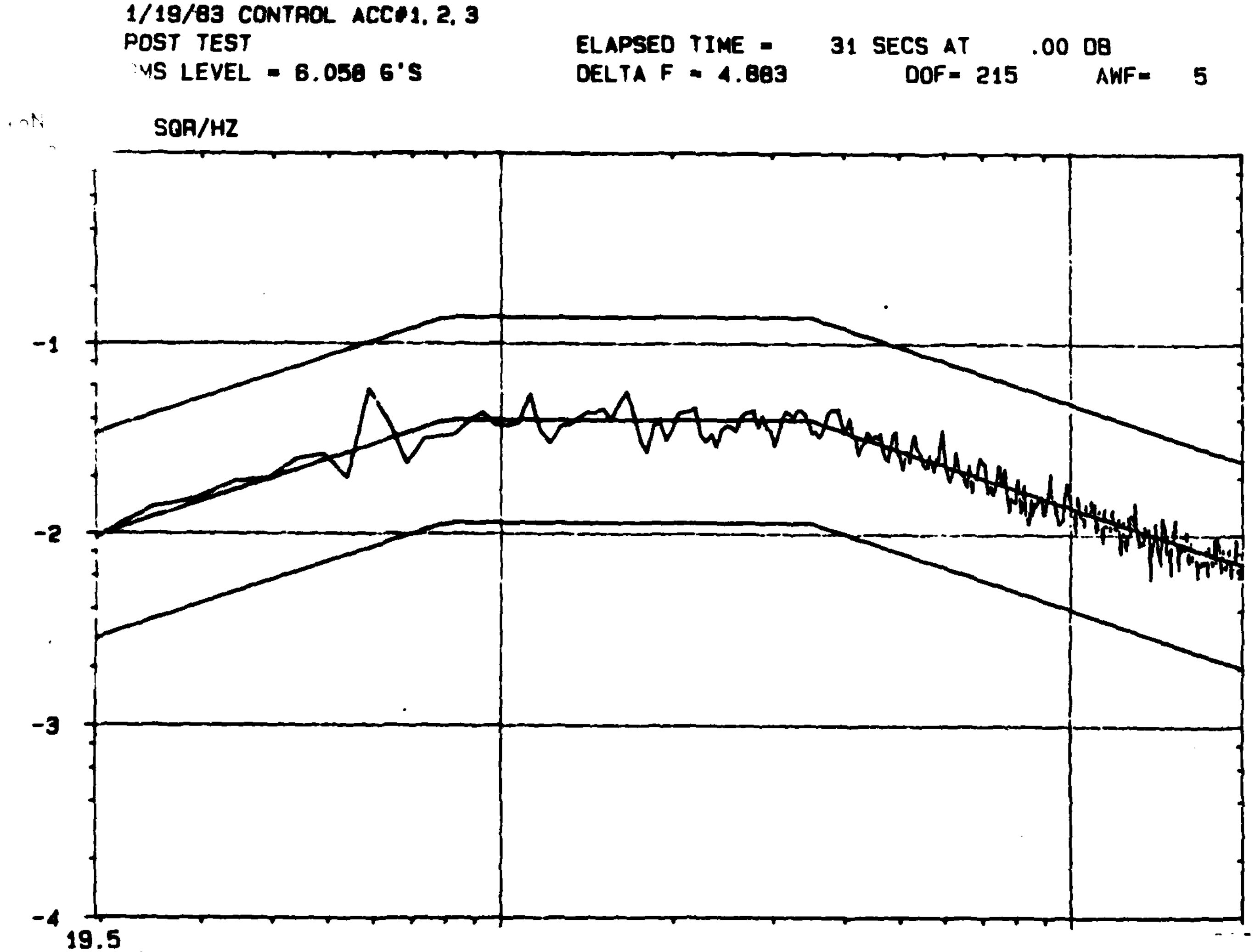

1/19/83 CONTROL ACC#1, 2, 3
POST TEST
MS LEVEL = 6.058 G'S
ELAPSED TIME = 31 SECS AT .00 DB
DELTA F = 4.883 DOF= 215 AWF= 5
SQR/HZ
-1
-2
-3
-4
19.5

Fig. C-22.

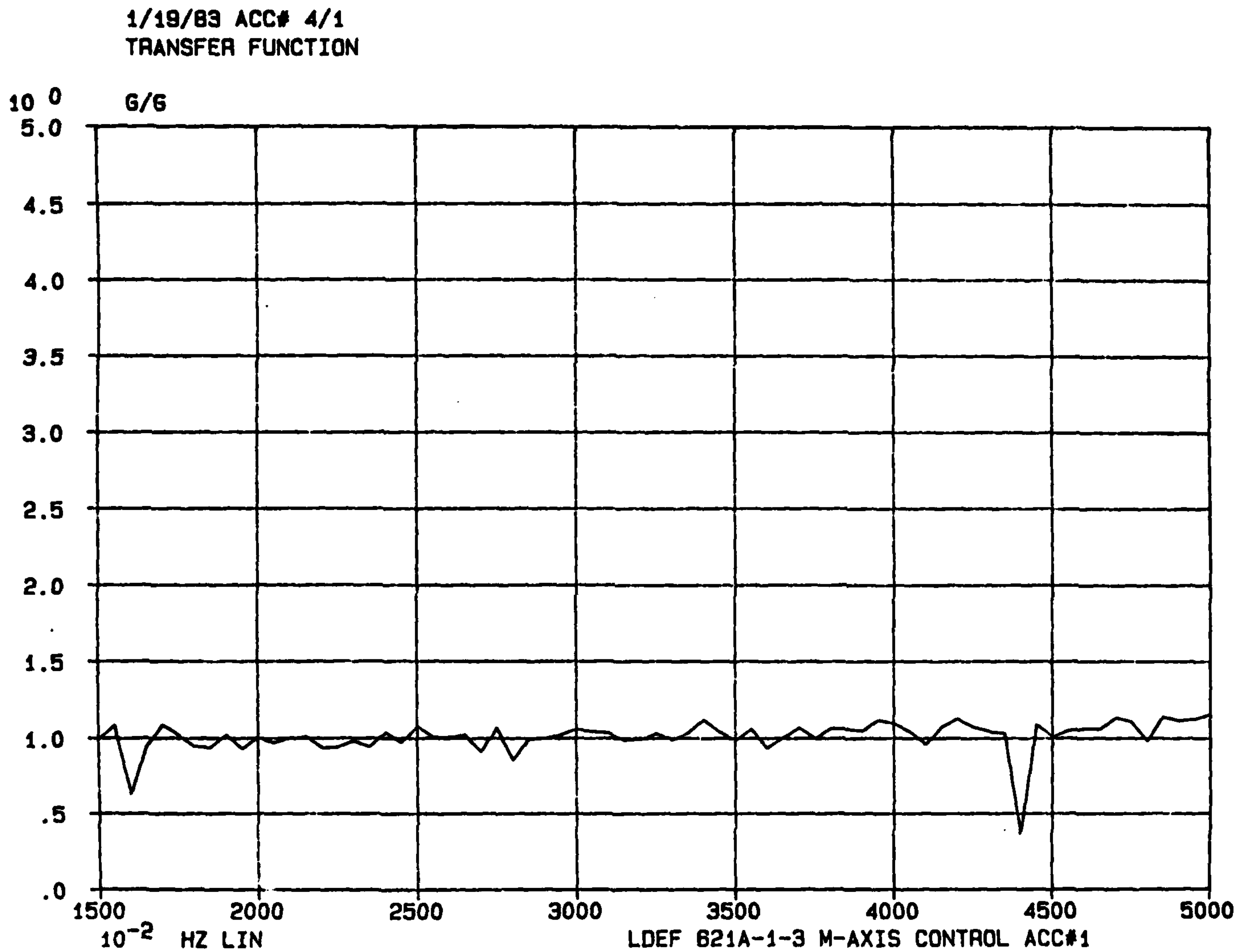

1/19/83 ACC# 4/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 621A-1-3 M-AXIS CONTROL ACC#1

Fig. C-23.

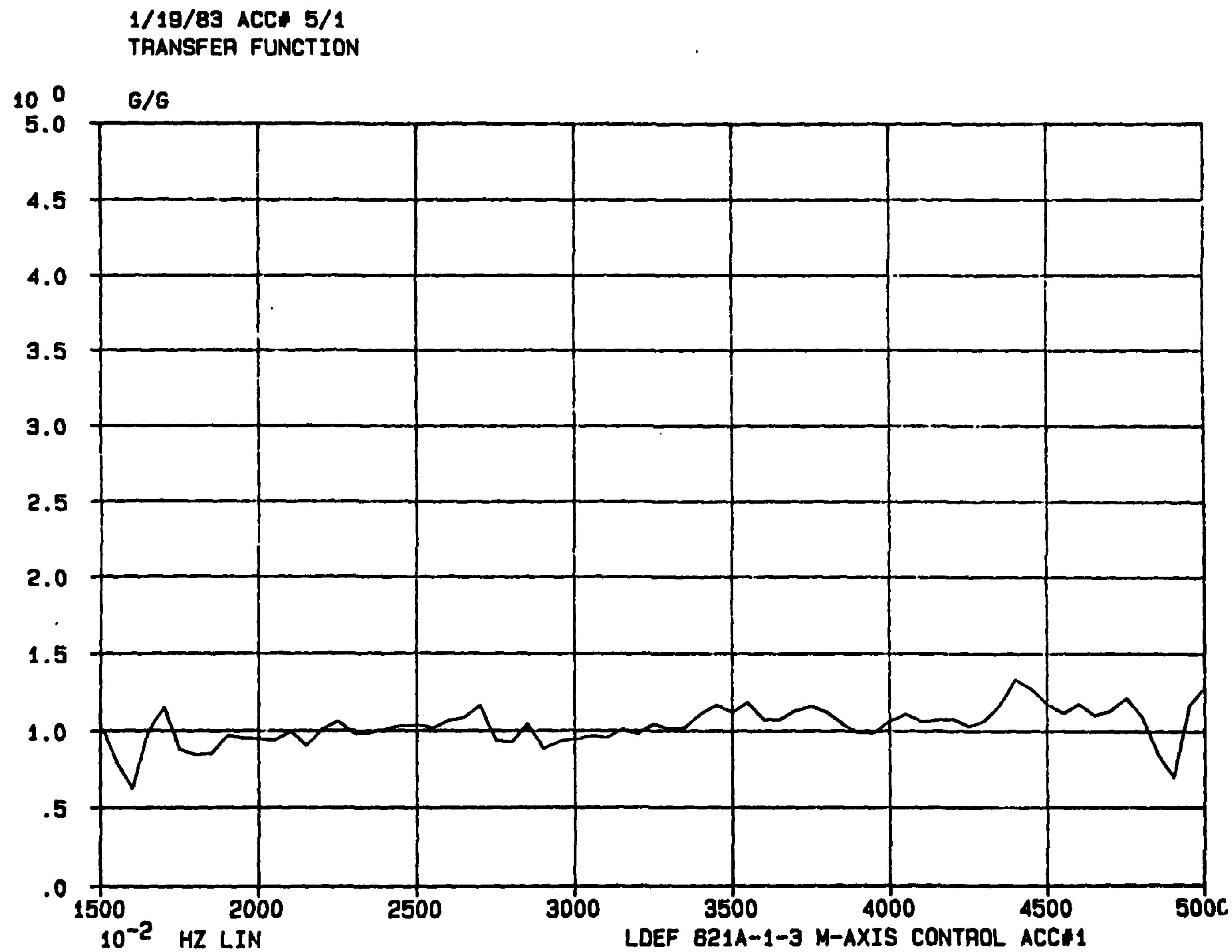

1/19/83 ACC# 5/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 821A-1-3 M-AXIS CONTROL ACC#1

Fig. C-24.

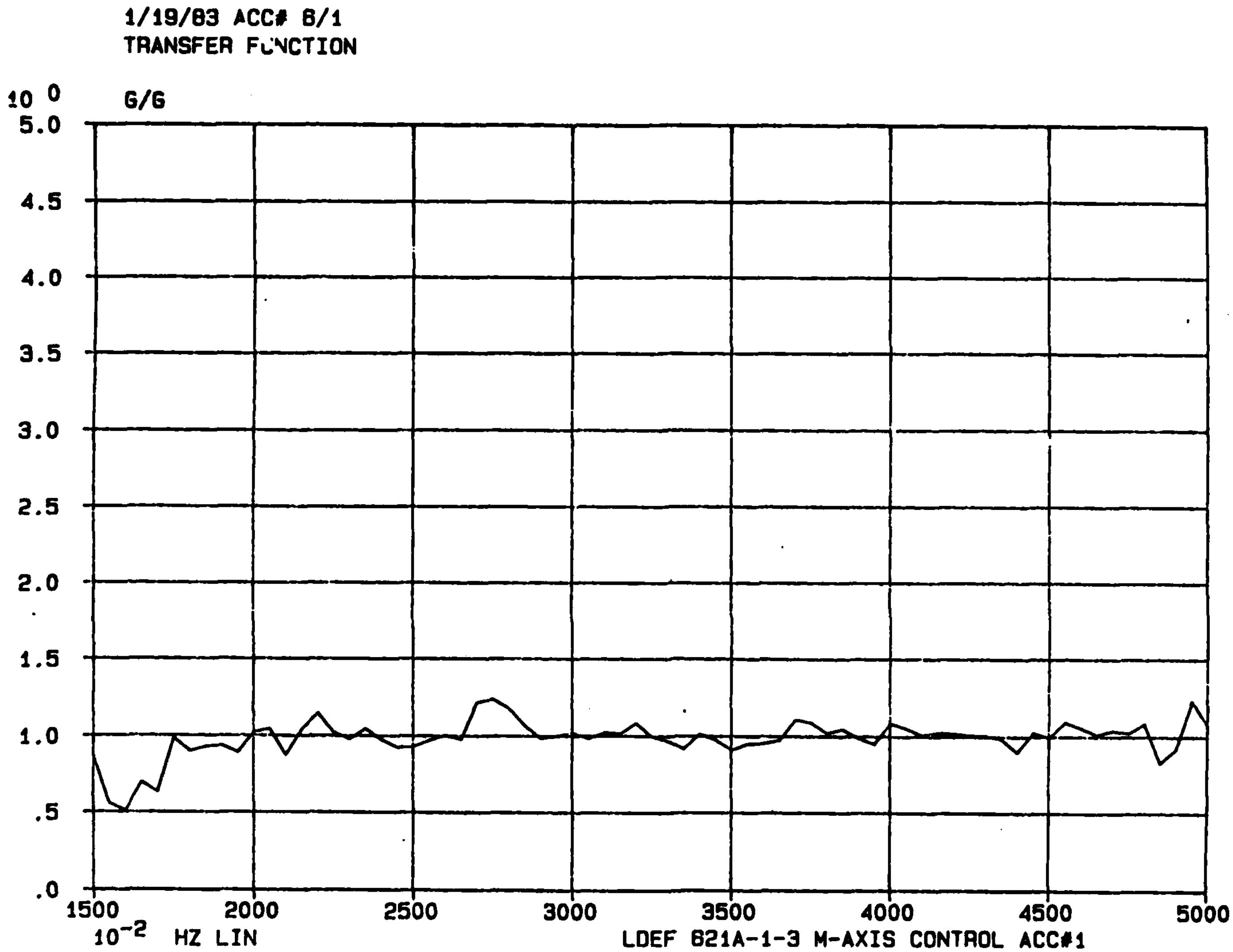

1/19/83 ACC# 6/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 621A-1-3 M-AXIS CONTROL ACC#1

Fig. C-25.

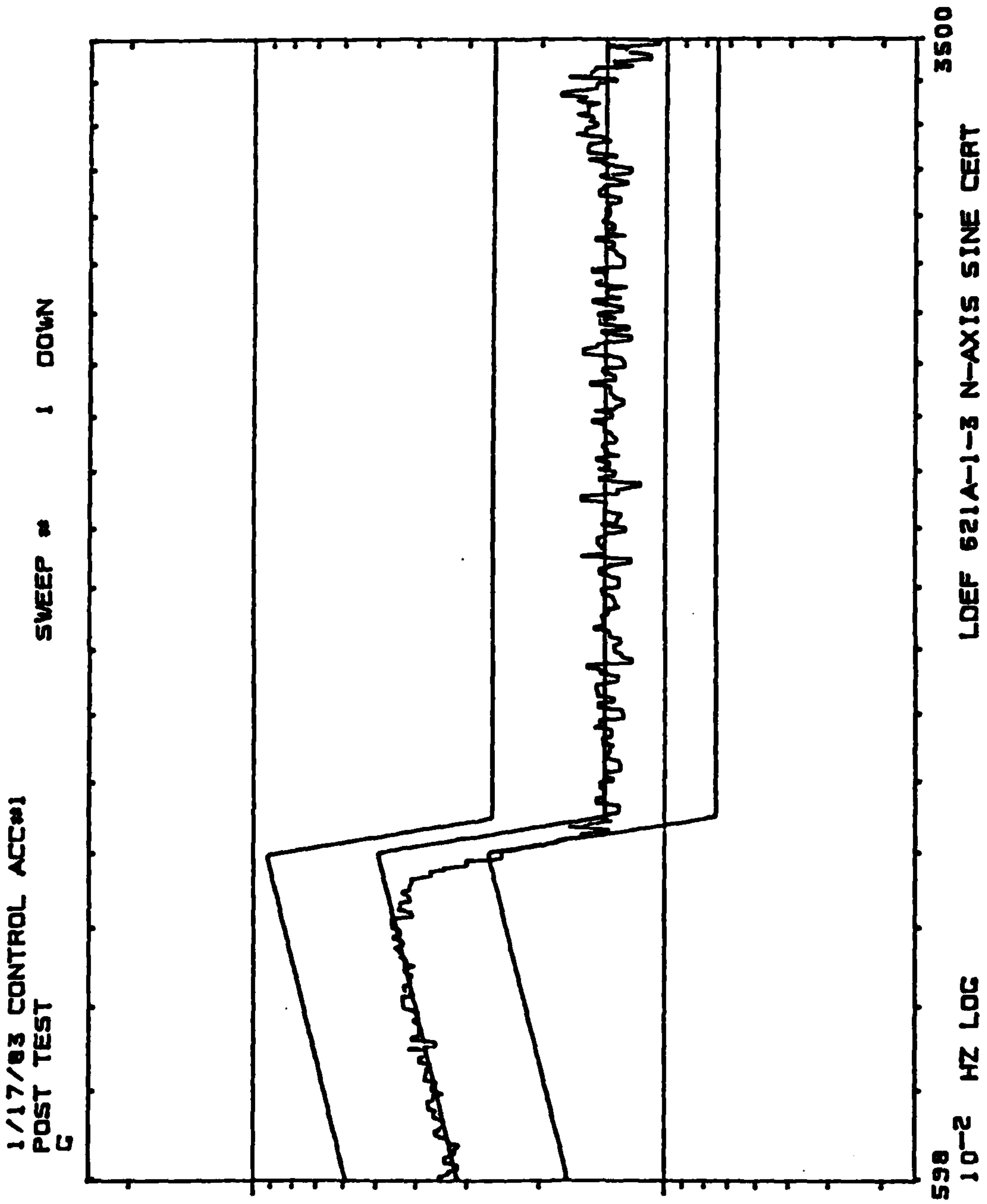

1/17/83 CONTROL ACC#1
POST TEST
G
SWEEP # 1 DOWN
10^N
1
0
15.98
10^{-2} HZ LOG
3500
LDEF 621A-1-3 N-AXIS SINE CERT

Fig. C-26.

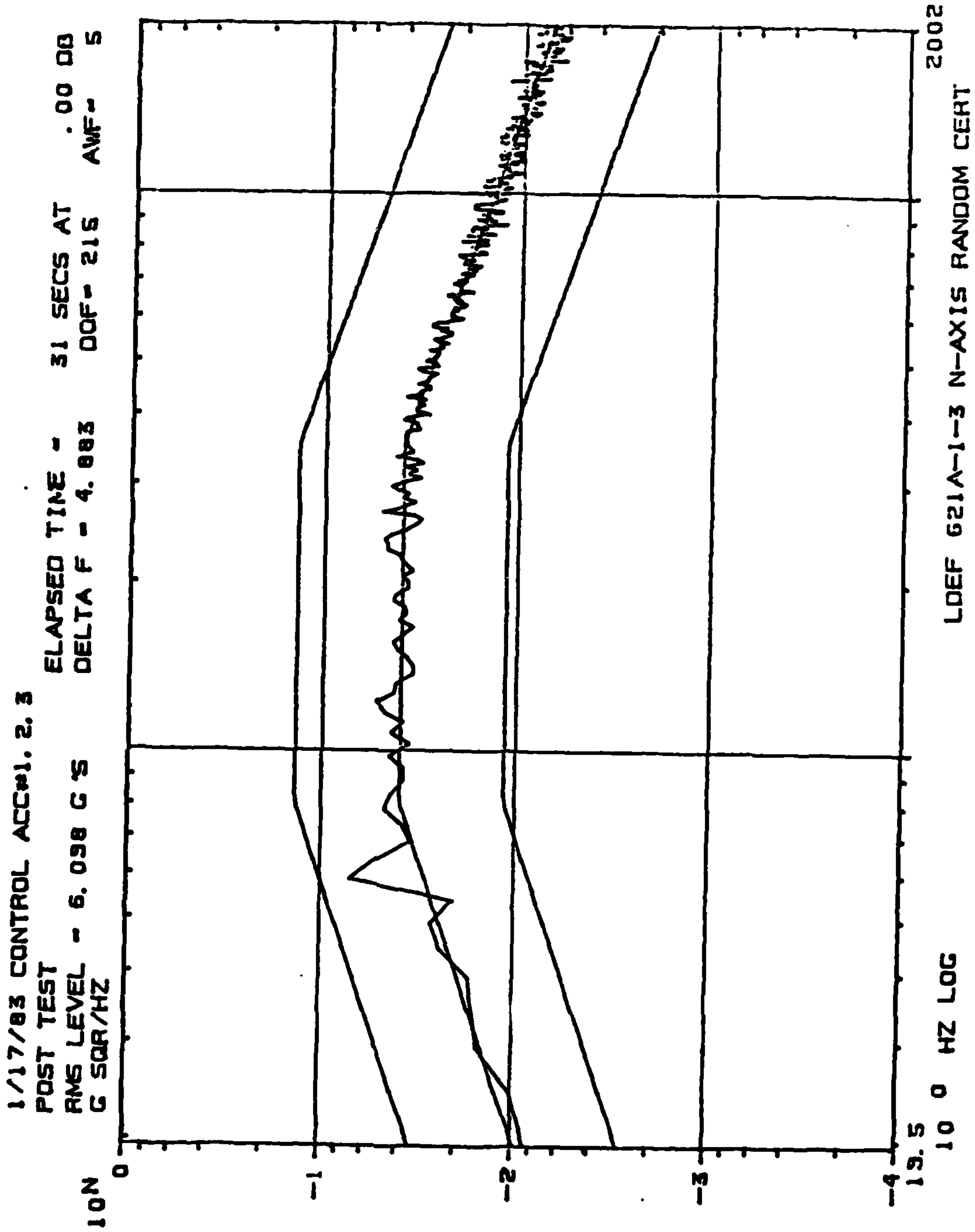

1/17/83 CONTROL ACC#1. 2. 3
POST TEST
RMS LEVEL = 6.098 G'S
G SQR/HZ
ELAPSED TIME = 31 SECS AT .00 DB
DELTA F = 4.883 DOF= 215 AWF= 5
10^N
0
-1
-2
-3
-4
13.5
10 0 HZ LOG
2002
LDEF G21A-1-3 N-AXIS RANDOM CERT

Fig. C-27.

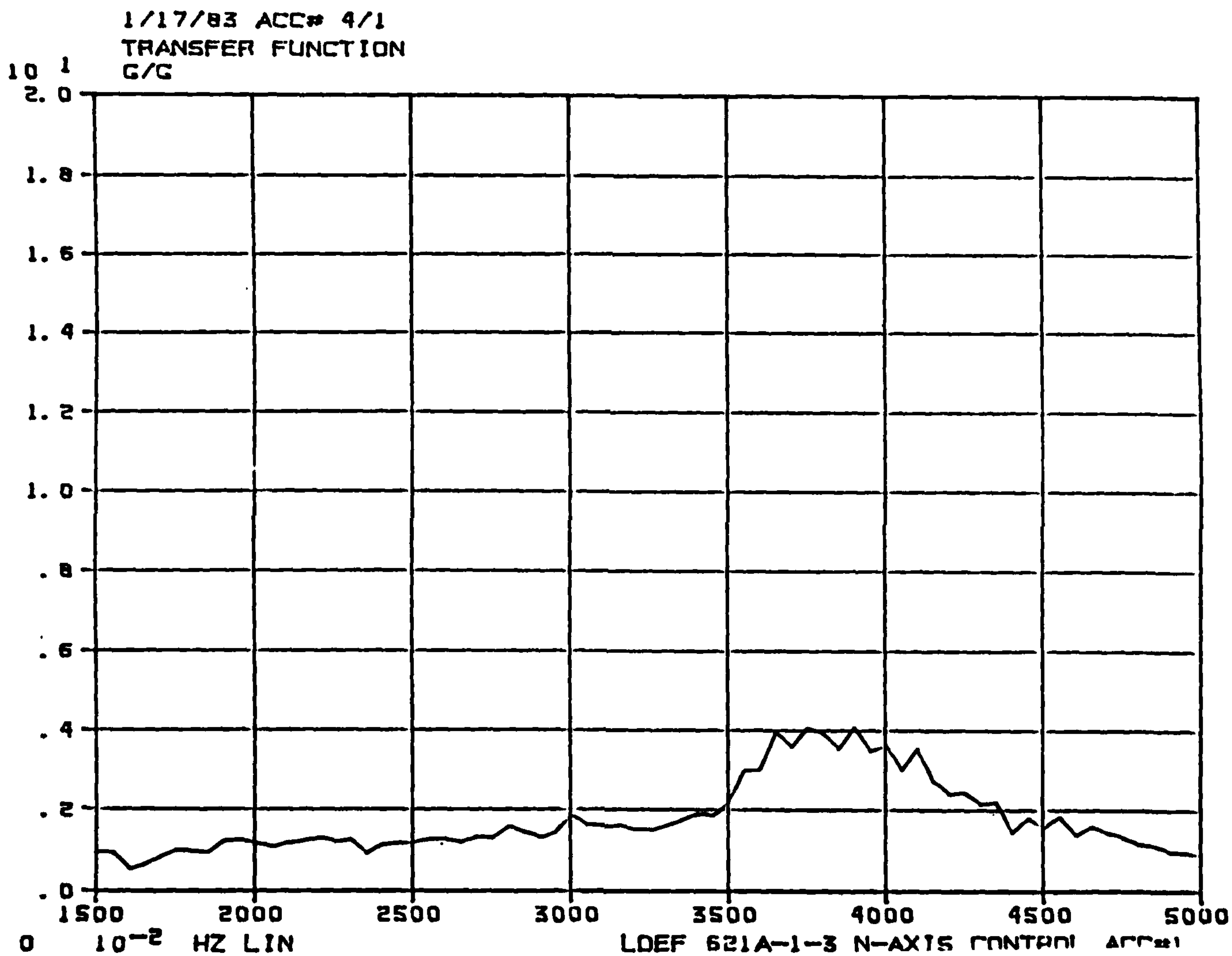

1/17/83 ACC# 4/1
TRANSFER FUNCTION
G/G
10 1
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
0
1500
2000
2500
3000
3500
4000
4500
5000
10−2 HZ LIN
LDEF 621A-1-3 N-AXIS

Fig. C-28.

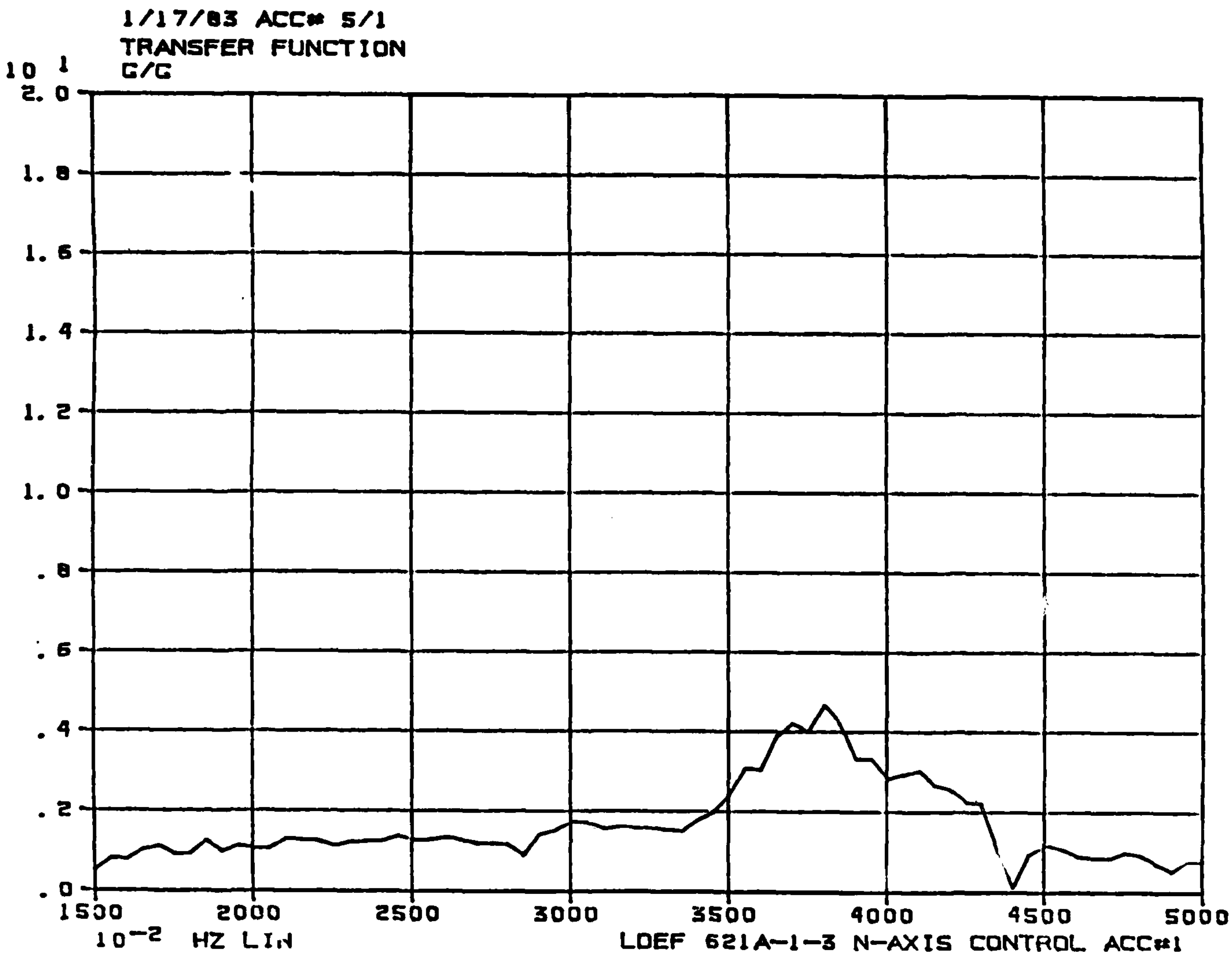

1/17/83 ACC# 5/1
TRANSFER FUNCTION
G/G
10 1
2. 0
1. 8
1. 6
1. 4
1. 2
1. 0
. 8
. 6
. 4
. 2
. 0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 621A-1-3 N-AXIS CONTROL ACC#1

Fig. C-29.

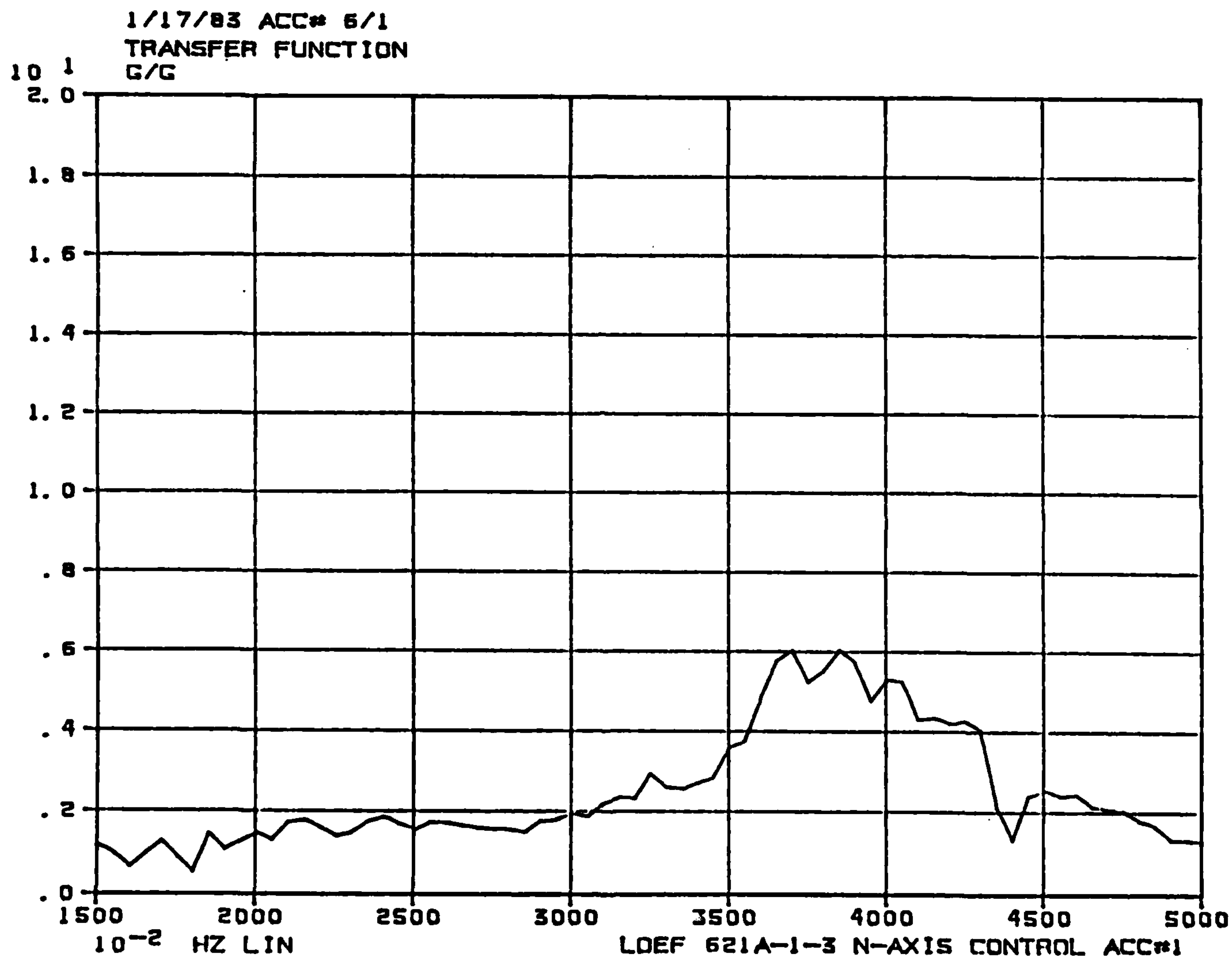

1/17/83 ACC# 6/1
TRANSFER FUNCTION
G/G
10 1
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
1500
2000
2500
3000
3500
4000
4500
5000
10−2 HZ LIN
LOEF 621A-1-3 N-AXIS CONTROL ACC#1

Fig. C-30.

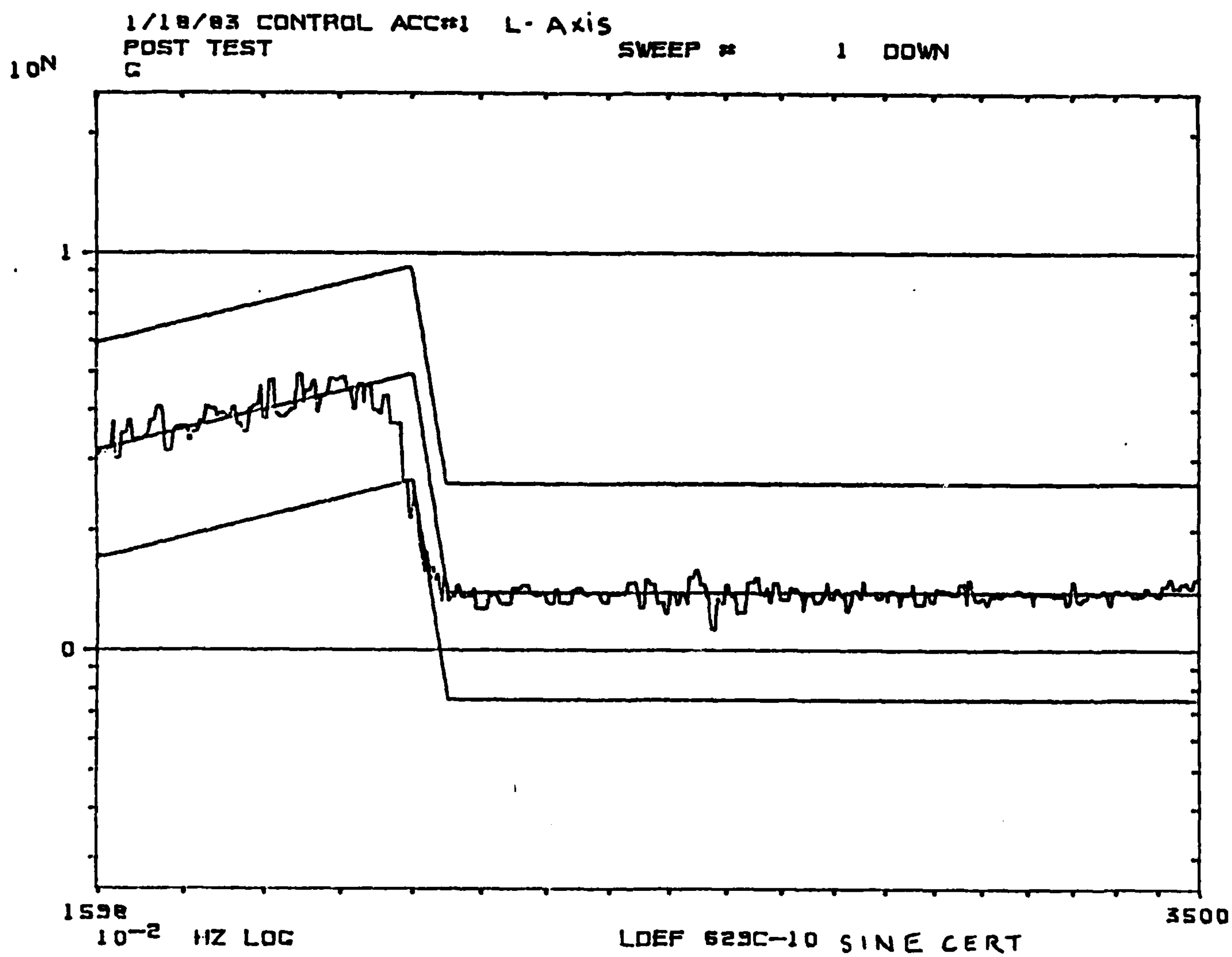

1/18/83 CONTROL ACC#1 L-Axis
POST TEST
SWEEP # 1 DOWN
10N
G
1
0
1598
3500
10-2 HZ LOG
LDEF 629C-10 SINE CERT

Fig. C-31.

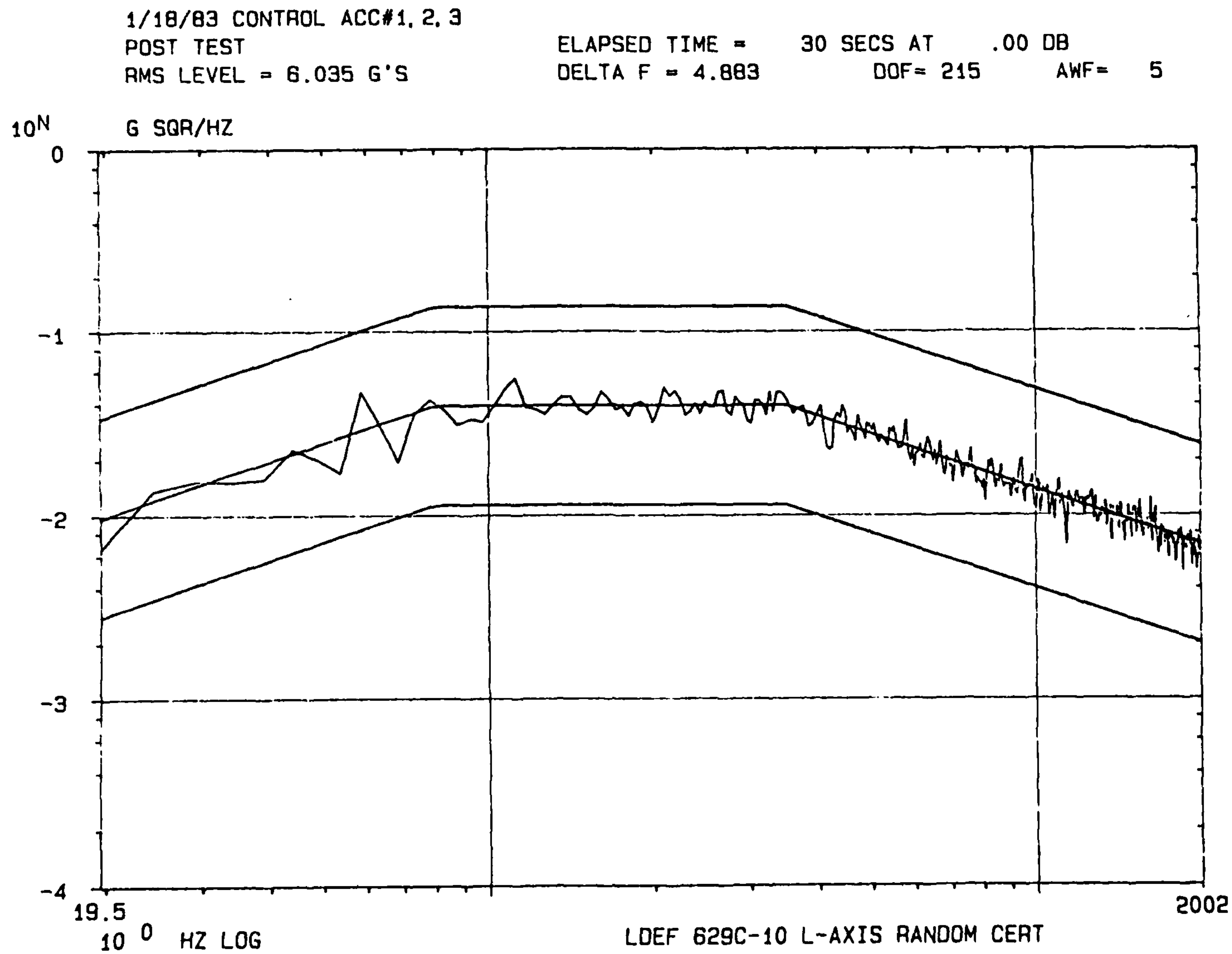
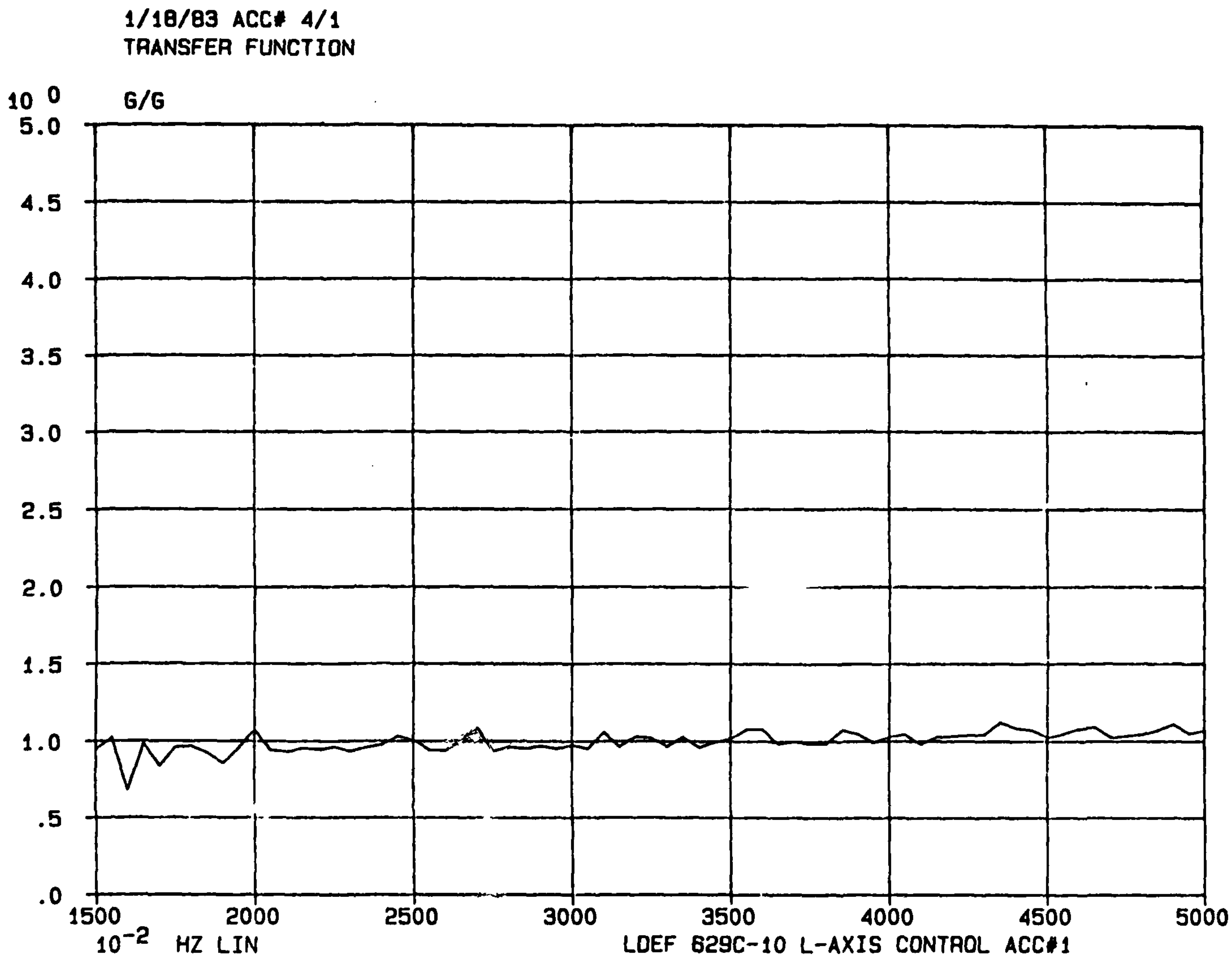

1/18/83 CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL = 6.035 G'S
ELAPSED TIME = 30 SECS AT .00 DB
DELTA F = 4.883 DOF= 215 AWF= 5
10N G SQR/HZ
0
-1
-2
-3
-4
19.5
10 0 HZ LOG
2002
LDEF 629C-10 L-AXIS RANDOM CERT

Fig. C-32.


1/18/83 ACC# 4/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 L-AXIS CONTROL ACC#1

F'g. C-33.

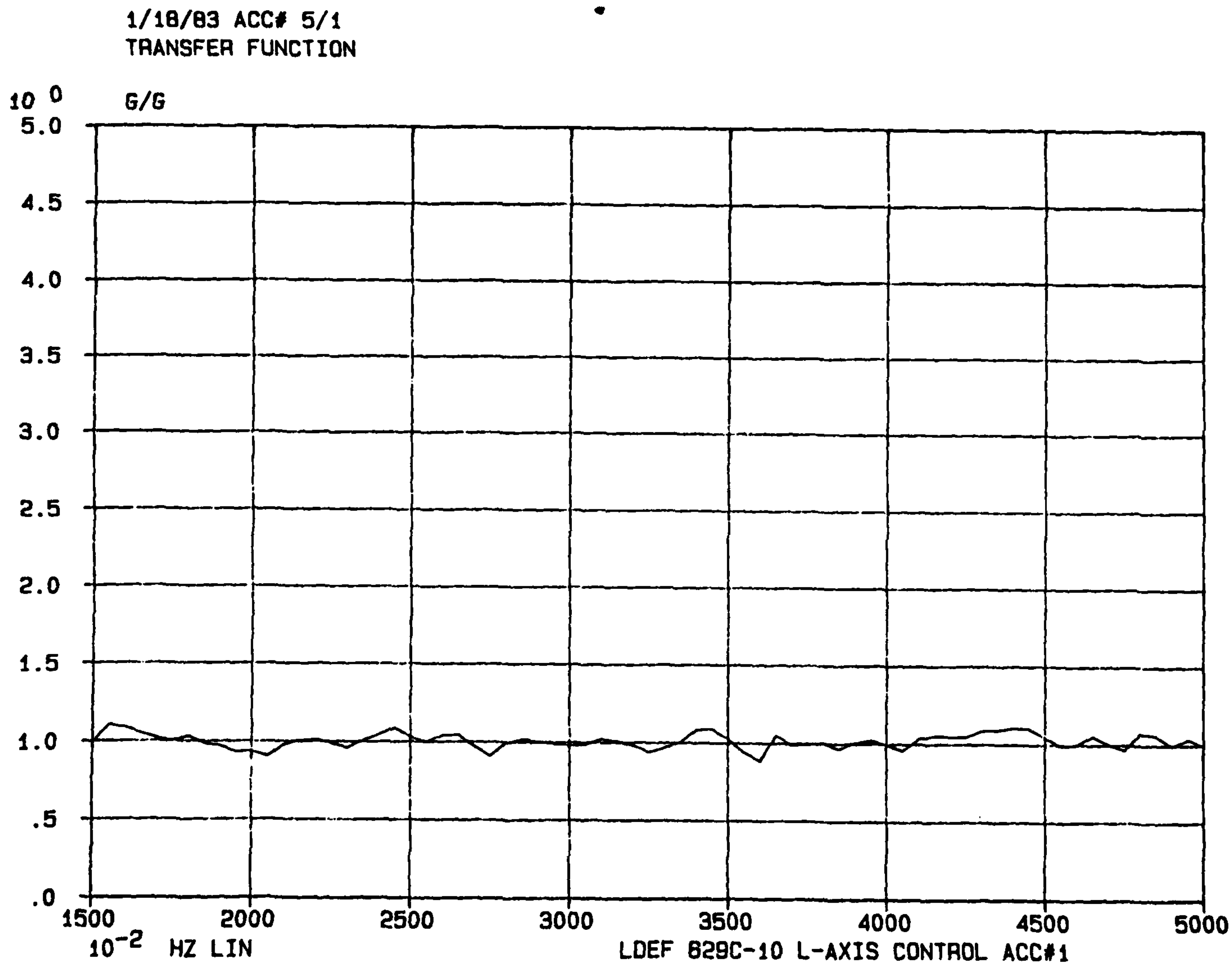

1/18/83 ACC# 5/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 829C-10 L-AXIS CONTROL ACC#1

Fig. C-34.

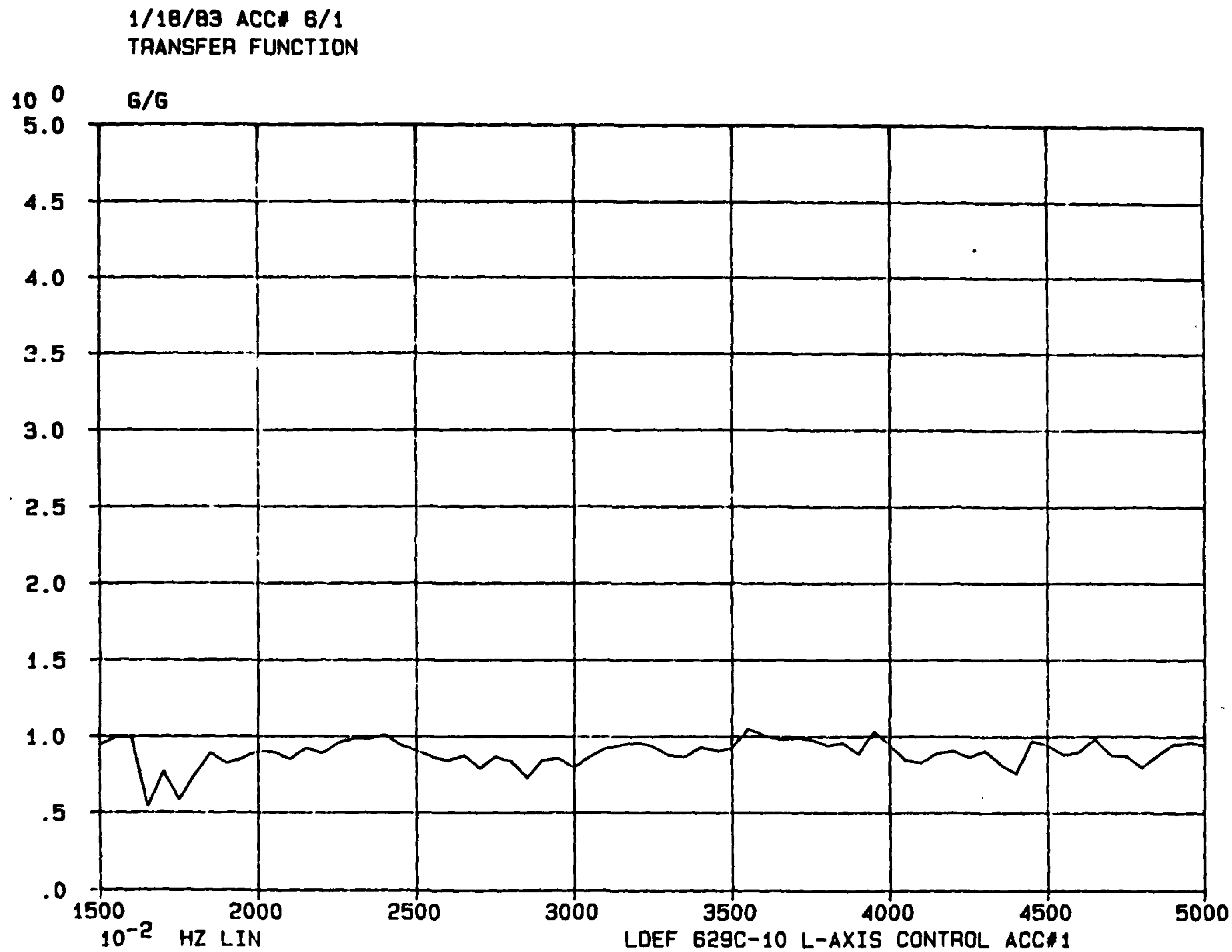

1/18/83 ACC# 6/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 L-AXIS CONTROL ACC#1

Fig. C-35.

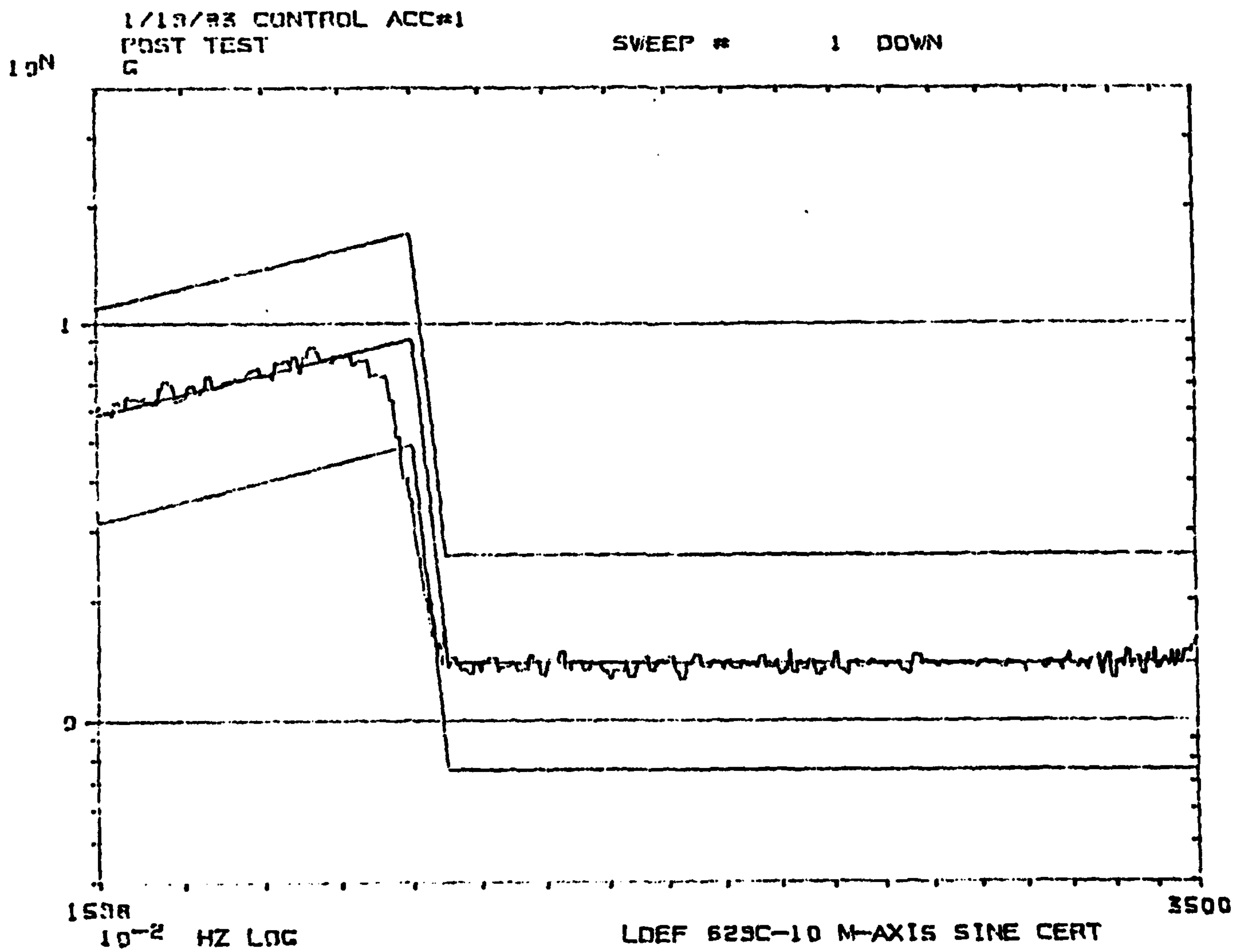

1/13/83 CONTROL ACC#1
POST TEST
G
SWEEP # 1 DOWN
10N
1
0
1508
10-2 HZ LOG
3500
LDEF 629C-10 M-AXIS SINE CERT

Fig. C-36.

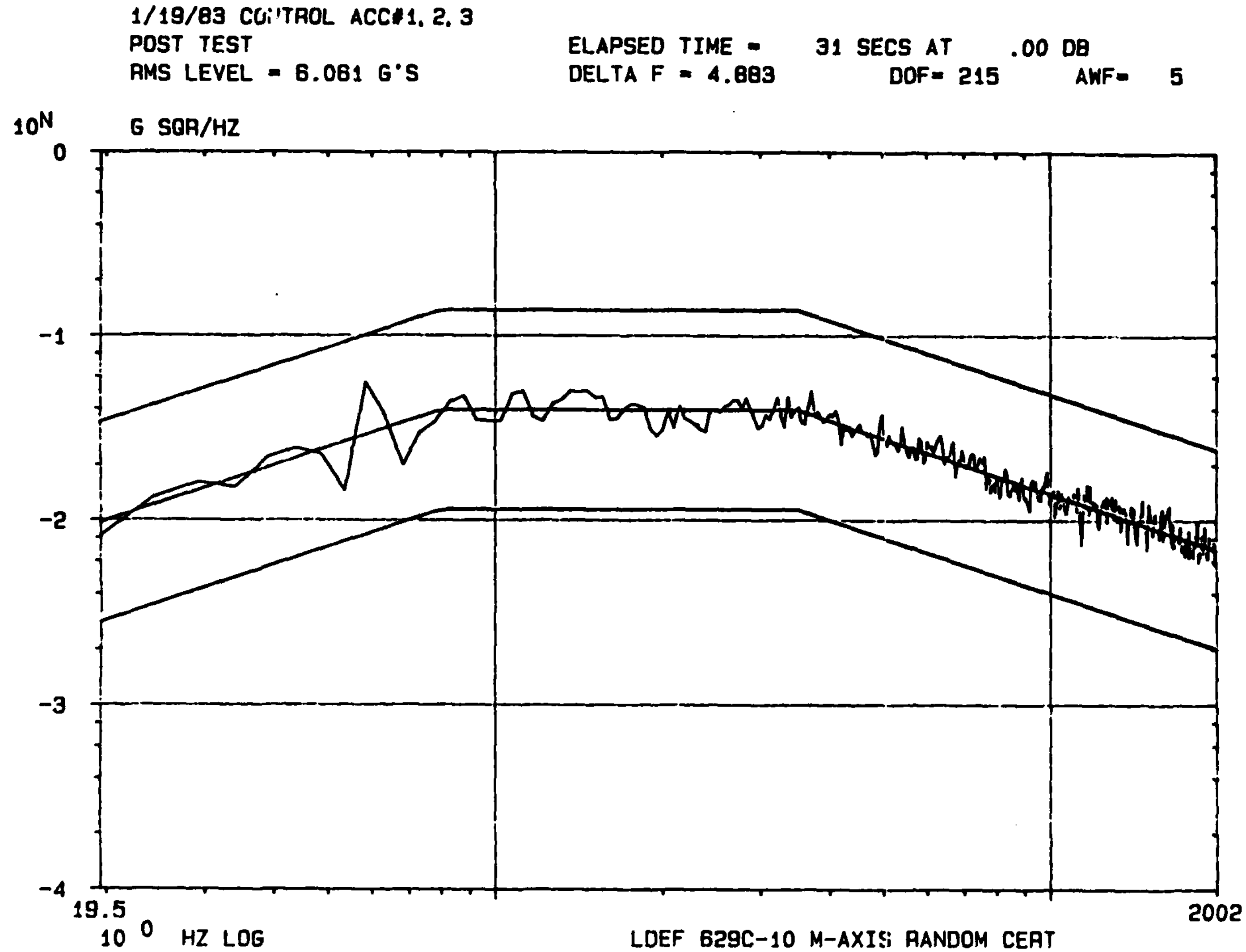

1/19/83 CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL = 6.061 G'S
ELAPSED TIME = 31 SECS AT .00 DB
DELTA F = 4.883
DOF= 215
AWF= 5
10N
G SQR/HZ
0
-1
-2
-3
-4
19.5
2002
10 0
HZ LOG
LDEF 629C-10 M-AXIS RANDOM CERT

Fig. C-37.

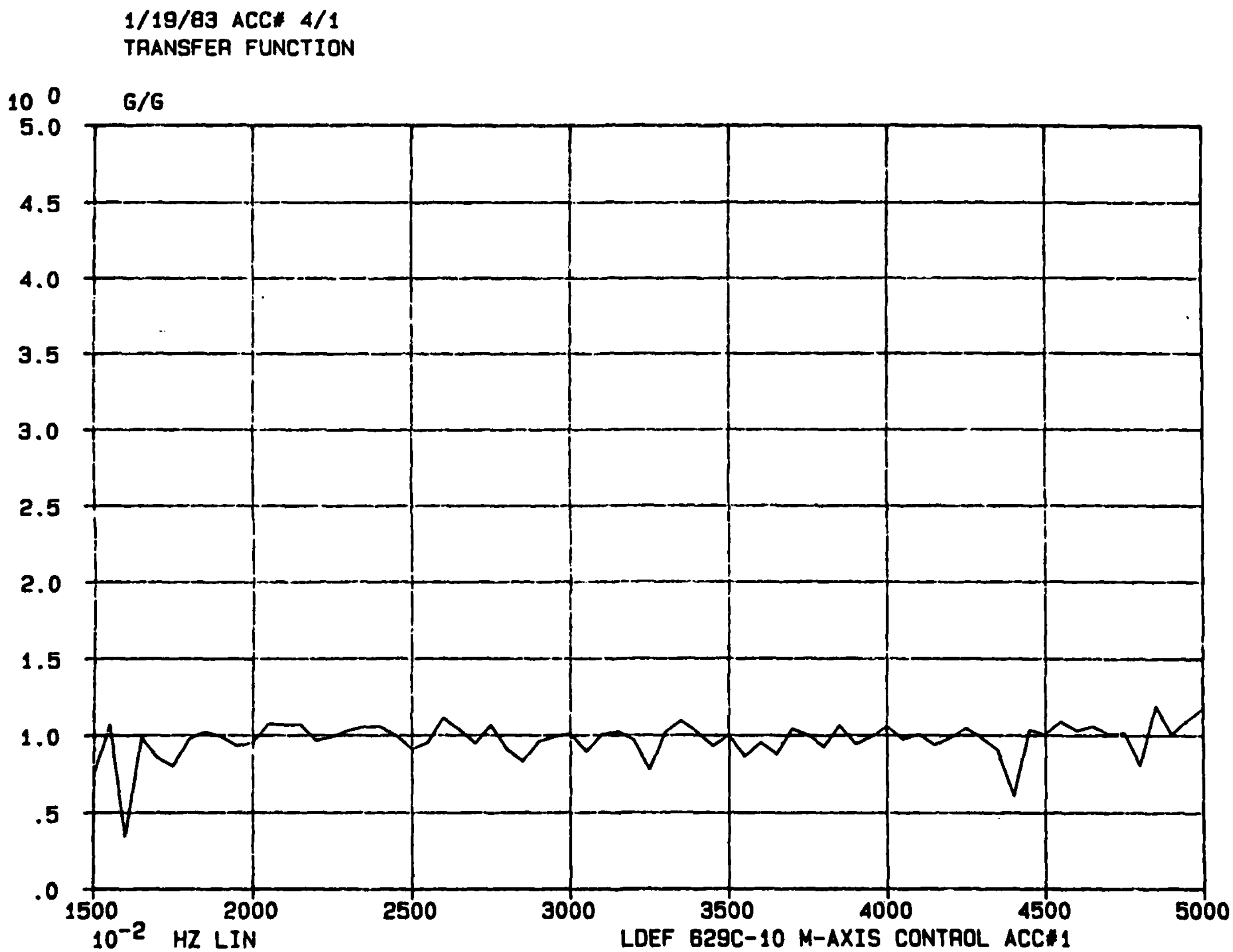
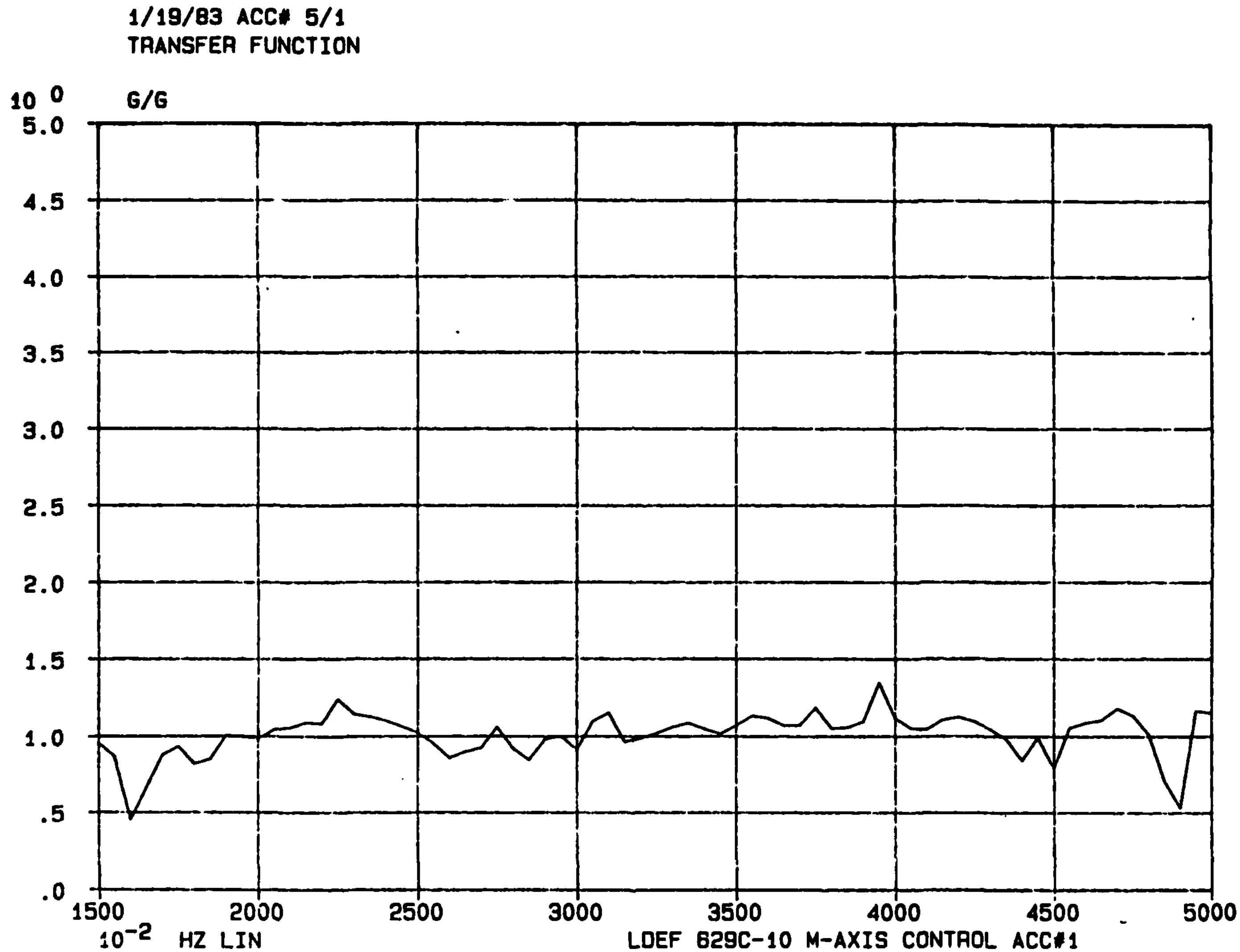

1/19/83 ACC# 4/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 M-AXIS CONTROL ACC#1

Fig. C-38.



1/19/83 ACC# 5/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 M-AXIS CONTROL ACC#1

Fig. C-39.

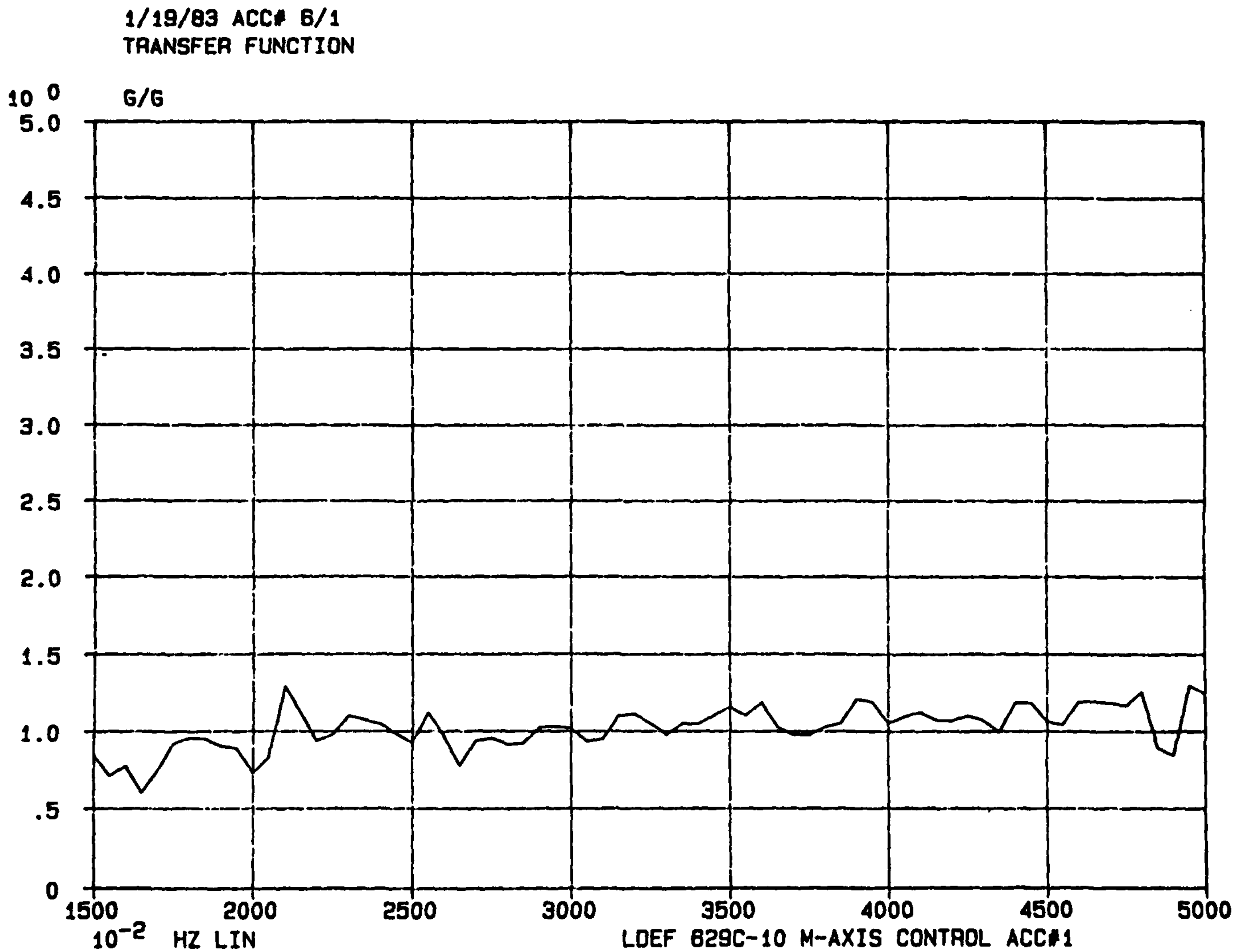

1/19/83 ACC# 6/1
TRANSFER FUNCTION
10 0
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 M-AXIS CONTROL ACC#1

Fig. C-40.

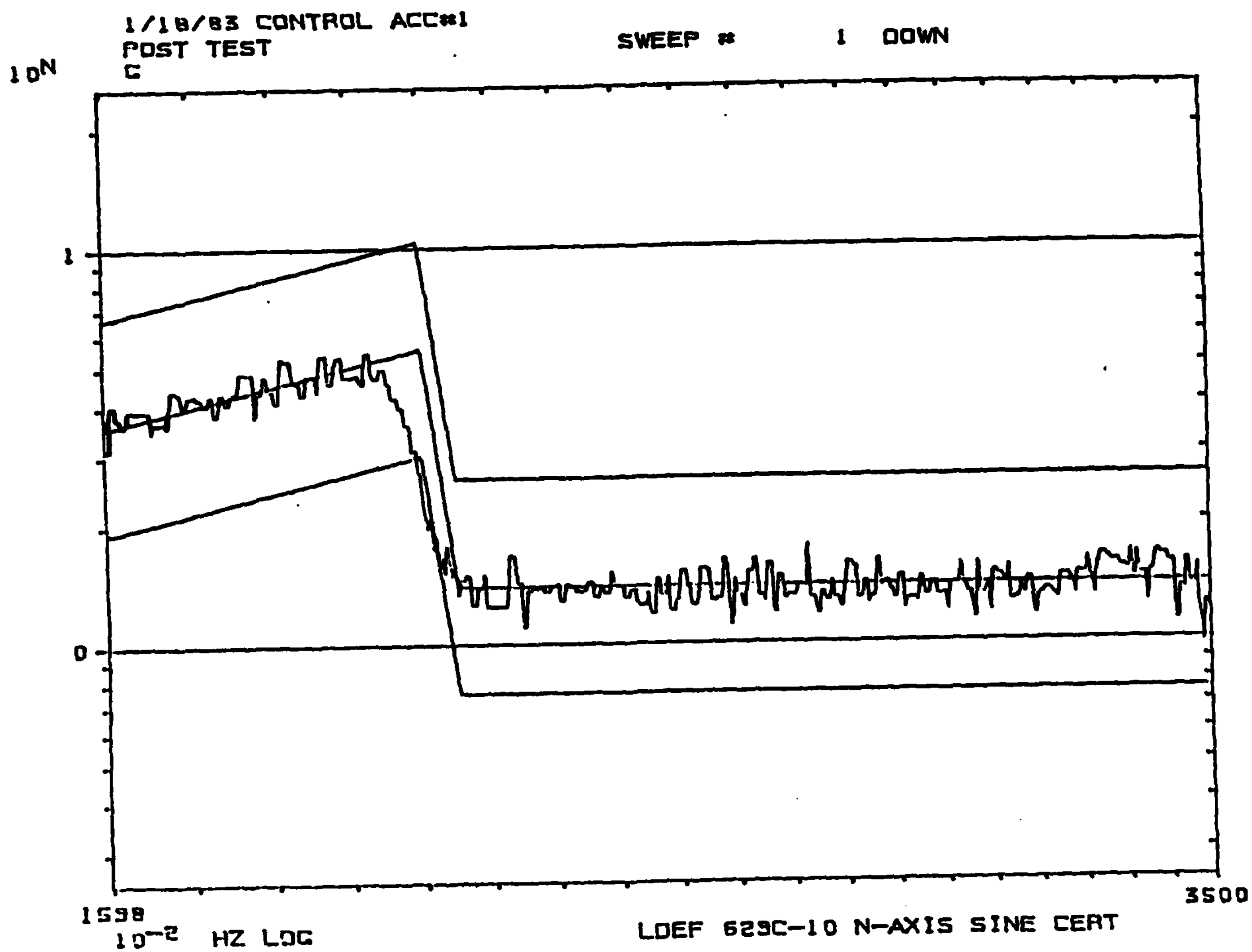
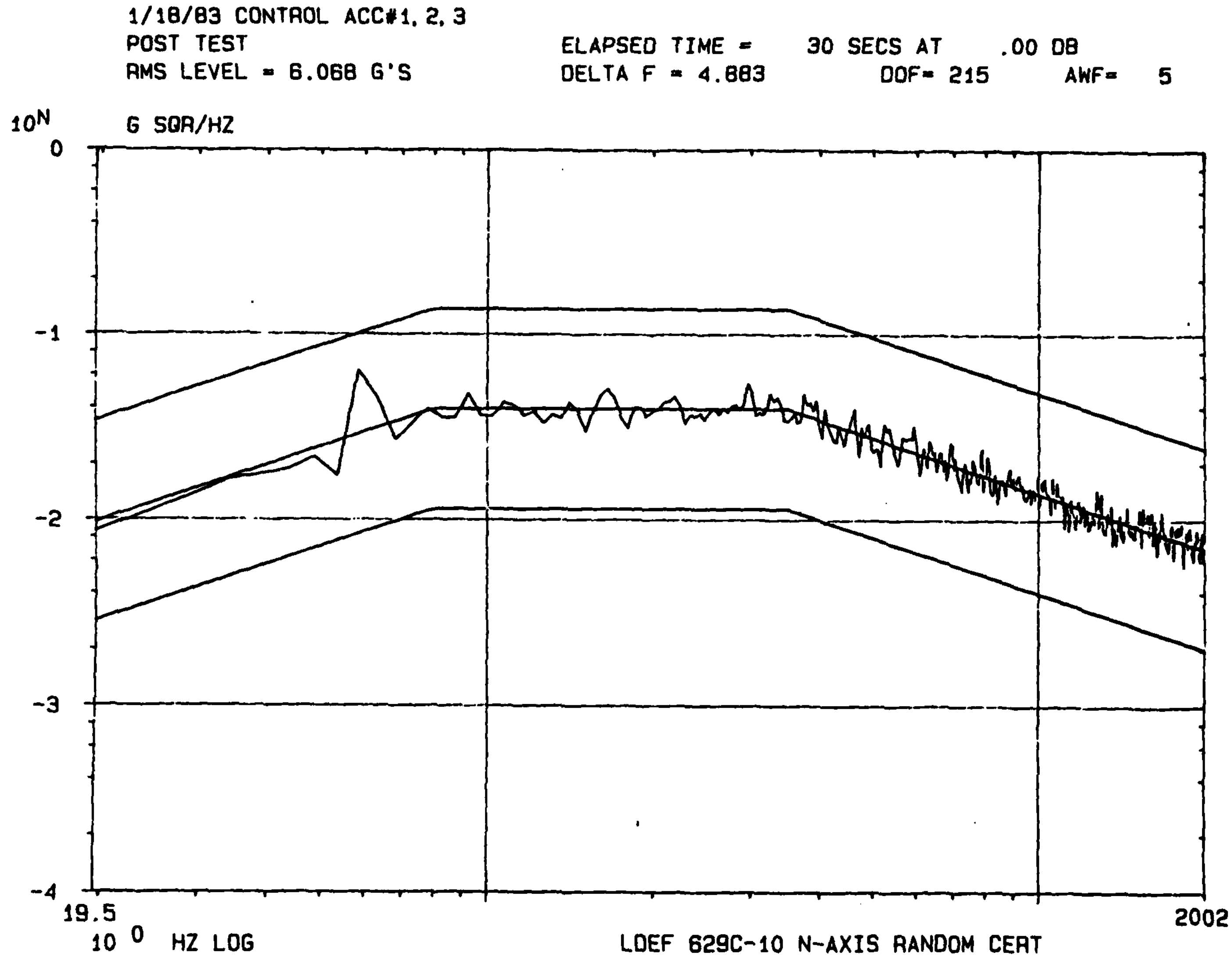

1/18/83 CONTROL ACC#1
POST TEST
C
SWEEP # 1 DOWN
10N
1
0
1598
10-2 HZ LOG
3500
LDEF 629C-10 N-AXIS SINE CERT

Fig. C-41.



1/18/83 CONTROL ACC#1, 2, 3
POST TEST
RMS LEVEL = 6.068 G'S
ELAPSED TIME = 30 SECS AT .00 DB
DELTA F = 4.883 DOF= 215 AWF= 5
10N
G SQR/HZ
0
-1
-2
-3
-4
19.5
2002
10 0 HZ LOG
LDEF 629C-10 N-AXIS RANDOM CERT

Fig. C-42.

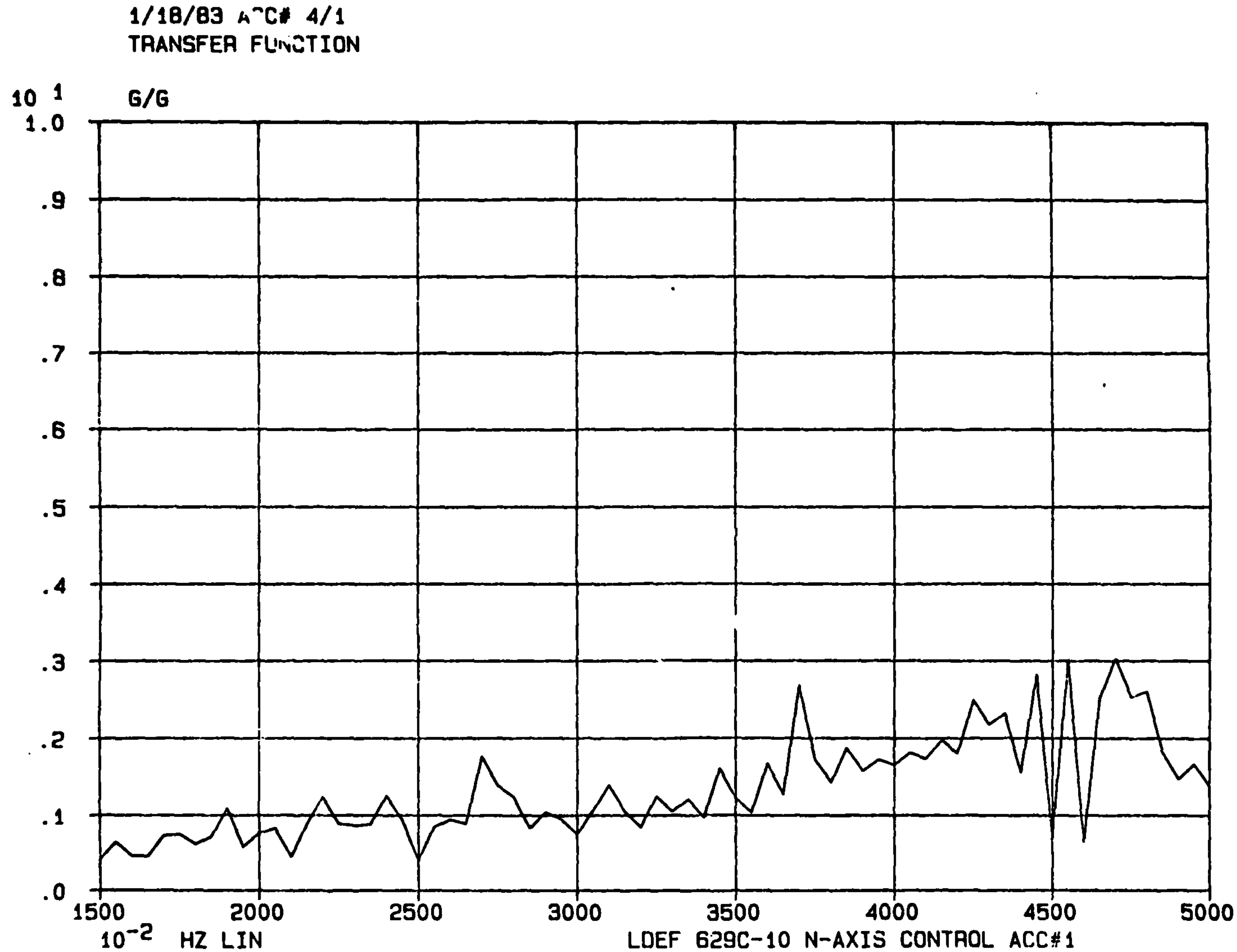

1/18/83 A^C# 4/1
TRANSFER FUNCTION
10 1
G/G
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 N-AXIS CONTROL ACC#1

Fig. C-43.

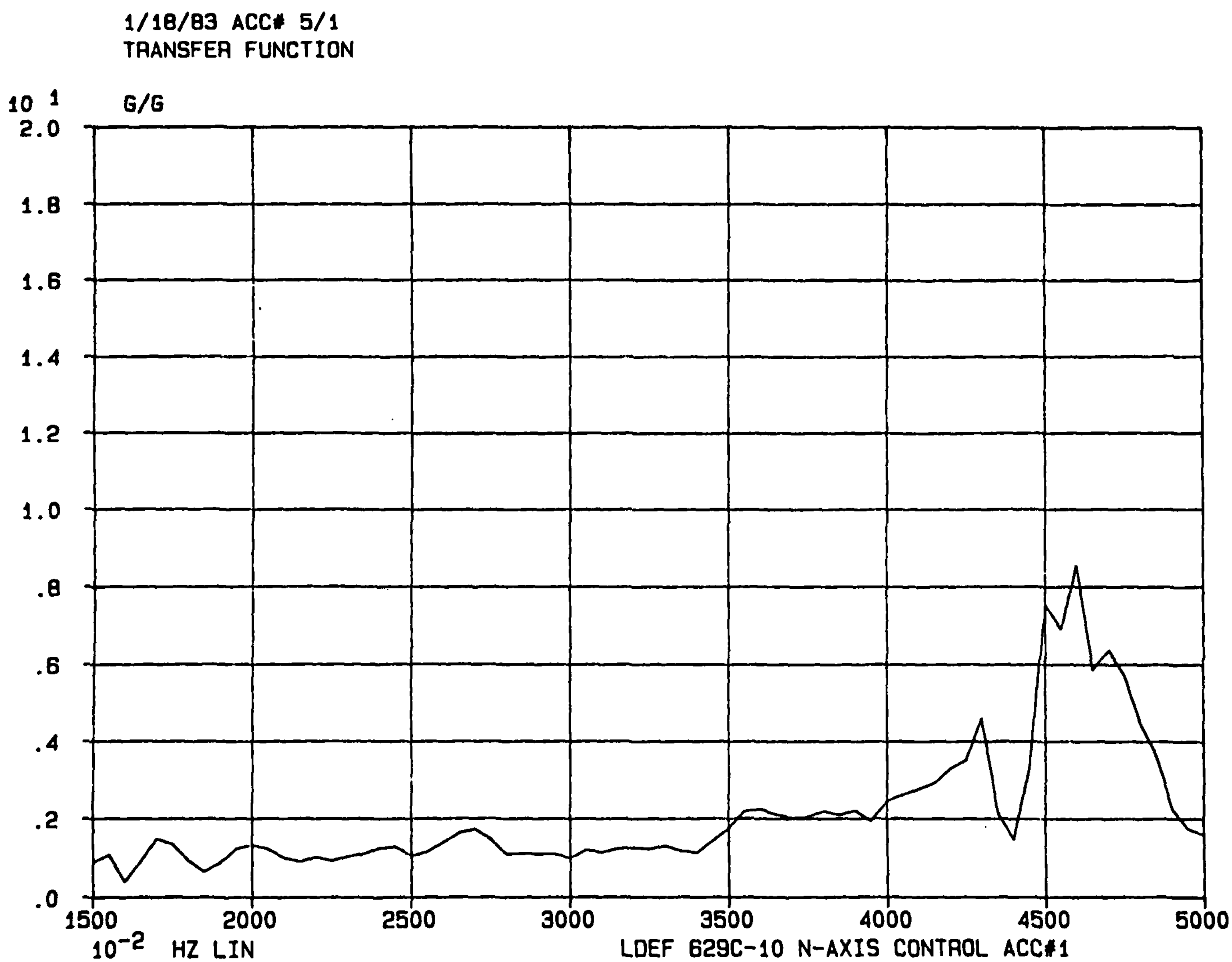

1/18/83 ACC# 5/1
TRANSFER FUNCTION
10 1
G/G
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 N-AXIS CONTROL ACC#1

Fig. C-44.

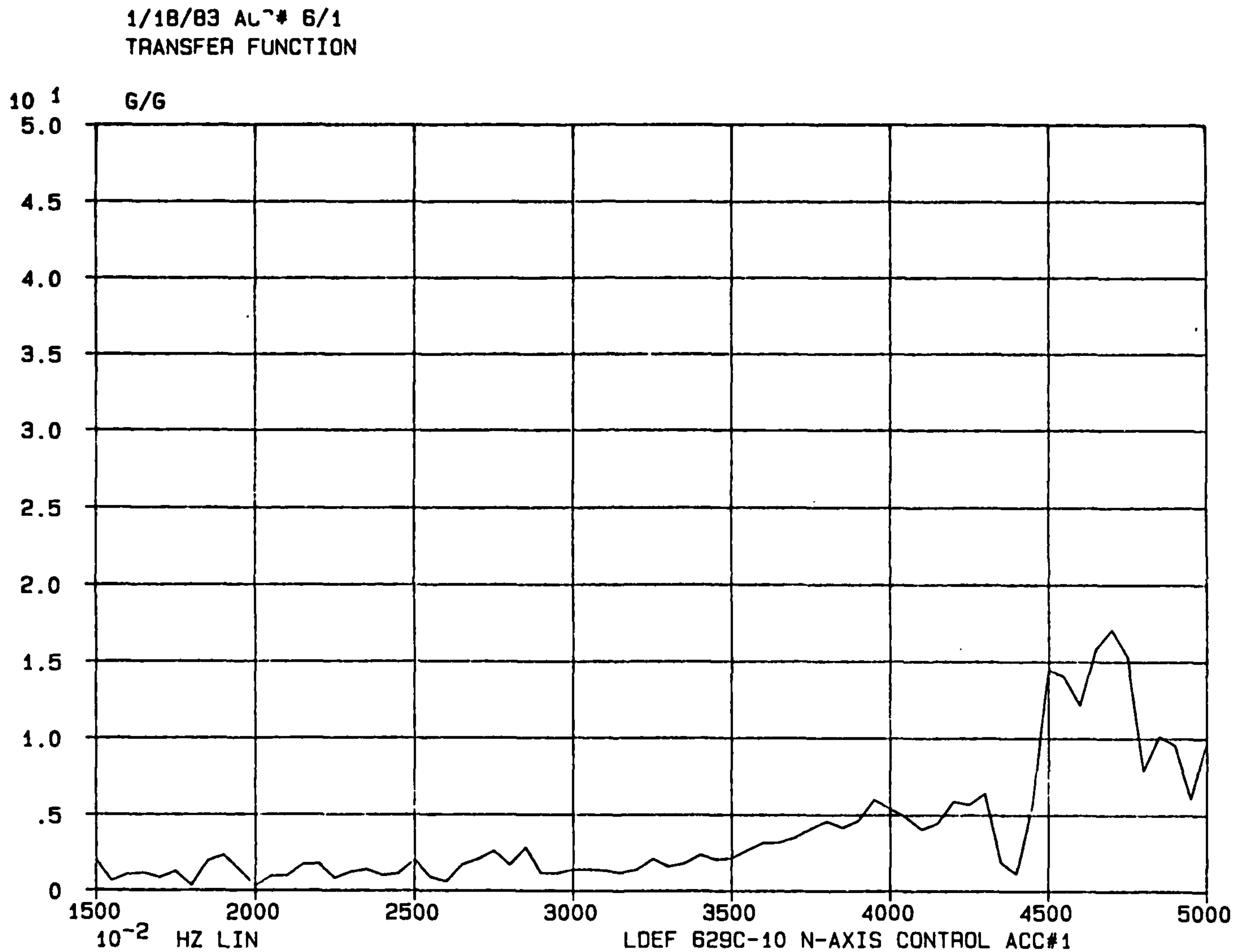

1/18/83 AC⁻# 6/1
TRANSFER FUNCTION
10 1
G/G
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
1500
2000
2500
3000
3500
4000
4500
5000
10-2 HZ LIN
LDEF 629C-10 N-AXIS CONTROL ACC#1

Fig. C-45.

LABORATORY OPERATIONS

The Laboratory Operations of The Aerospace Corporation is conducting experimental and theoretical investigations necessary for the evaluation and application of scientific advances to new military space systems. Versatility and flexibility have been developed to a high degree by the laboratory personnel in dealing with the many problems encountered in the nation's rapidly developing space systems. Expertise in the latest scientific developments is vital to the accomplishment of tasks related to these problems. The laboratories that contribute to this research are:

Aerophysics Laboratory: Launch vehicle and reentry aerodynamics and heat transfer, propulsion chemistry and fluid mechanics, structural mechanics, flight dynamics; high-temperature thermomechanics, gas kinetics and radiation; research in environmental chemistry and contamination; cw and pulsed chemical laser development including chemical kinetics, spectroscopy, optical resonators and beam pointing, atmospheric propagation, laser effects and countermeasures.

Chemistry and Physics Laboratory: Atmospheric chemical reactions, atmospheric optics, light scattering, state-specific chemical reactions and radiation transport in rocket plumes, applied laser spectroscopy, laser chemistry, battery electrochemistry, space vacuum and radiation effects on materials, lubrication and surface phenomena, thermionic emission, photosensitive materials and detectors, atomic frequency standards, and bioenvironmental research and monitoring.

Electronics Research Laboratory: Microelectronics, GaAs low-noise and power devices, semiconductor lasers, electromagnetic and optical propagation phenomena, quantum electronics, laser communications, lidar, and electro-optics; communication sciences, applied electronics, semiconductor crystal and device physics, radiometric imaging; millimeter-wave and microwave technology.

Information Sciences Research Office: Program verification, program translation, performance-sensitive system design, distributed architectures for spaceborne computers, fault-tolerant computer systems, artificial intelligence, and microelectronics applications.

Materials Sciences Laboratory: Development of new materials: metal matrix composites, polymers, and new forms of carbon; component failure analysis and reliability; fracture mechanics and stress corrosion; evaluation of materials in space environment; materials performance in space transportation systems; analysis of systems vulnerability and survivability in enemy-induced environments.

Space Sciences Laboratory: Atmospheric and ionospheric physics, radiation from the atmosphere, density and composition of the upper atmosphere, aurorae and airglow; magnetospheric physics, cosmic rays, generation and propagation of plasma waves in the magnetosphere; solar physics, infrared astronomy; the effects of nuclear explosions, magnetic storms, and solar activity on the earth's atmosphere, ionosphere, and magnetosphere; the effects of optical, electromagnetic, and particulate radiations in space on space systems.

MED

-8